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First Report of Insect Galls on *Ficus microcarpa* in Penghu Islands, Taiwan

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Abstract. The morphology of insect galls often has a species-specific relation to gall-inducers. Therefore, using gall morphotypes as a surrogate of insect species, researchers can preliminarily investigate the gall-inducing insect fauna of an area. The Penghu Islands are the largest offshore islands of Taiwan, but the gall-inducing insect fauna is poorly known. In this study, we selected the widespread Chinese banyan (*Ficus microcarpa* L.) as the target of our faunistic survey focused on gall-inducing insects. We collected insect galls on *F. microcarpa* in Magong island, Baisha island and Xiyu island from September 2020 to February 2021. A total of 4 gall morphotypes were newly recorded in the islands. These gall morphotypes were induced by *Horidiplosis* sp. and an unidentified gall midge (Diptera: Cecidomyiidae, 2 morphotypes), *Macrohomotoma gladiata* Kuwayama (Hemiptera: Carsidaridae), and *Gynaikothrips* sp. (Thysanoptera: Phlaeothripidae, 1 morphotype). We infer and discuss the potential taxonomic position of each gall-inducing insect based on given specimens and gall morphotypes. Gall-inducing insects on *F. microcarpa* in Penghu Islands might naturally disperse from neighboring regions, such as mainland China or Taiwan Island, but there is a possibility that gall-inducing insects were introduced from the southern part of Taiwan Island due to the import of nursery trees for the afforestation project in the 1910s. Further molecular work could help clarify the origin of the gall-inducing insects on *F. microcarpa* in Penghu Islands.

Key words: Cecidomyiidae, Carsidaridae, *Gynaikothrips*, native plant

Introduction

Gall-inducing insects are one of the most specialized types of herbivores that induce galls, abnormal growth, on the host plant to gain nourishment, shelter and protection (Price et al., 1987; Stone & Schönrogge, 2003; Shorthouse et al., 2005). Most gall-inducing insects dwell inside galls before reaching adult stage (Mani, 1992). Although gall-inducing insects have the conspicuous habit, their species classification is often deficient, especially in tropical regions (Espírito-Santo & Fernandes, 2007). The lifetime of adults is relatively short, and therefore adult specimens are not readily available. This situation makes taxonomic study of gall-inducing insects particularly difficult. However, galls are immobile, relatively noticeable in the wild, and exist after adults' emergence. In addition, most gall-inducing insects are highly specific to their host plants and plant organs (Dreger-Jauffret & Shorthouse, 1992). Species classification of gall-inducing insects can be tentatively defined into gall morphotypes according to the combination of their host plants, host organs, and the external morphology (Fernandes & Price, 1988; Price et al., 1998; Carneiro et al., 2009). Therefore, gall morphotypes have been considered as species units in ecological studies (Yukawa, 2018).

The faunistic studies of Taiwanese gall-inducing insects started in 1995 (Yang & Tung, 1998; Yang et al., 2000a, b; Tung et al., 2006; Yang et al., 2006; Pan et al., 2018). These studies used gall morphotypes to estimate the species diversity of gall-inducing insects. Although the above-mentioned studies included offshore islands, the gall-inducing insect diversity might be underestimated due to the lack of a comprehensive investigation. The Penghu Islands, consisting of 90 small islands with a total land area of ~127 km^2, are situated away from the west coast of Chiayi County (western Taiwan Island) about 50 km. The spatial range of the Penghu Islands spans 23°12'–23°47'N and 119°19'–119°43'E. The Penghu Islands are volcanic islands, and are the largest offshore islands of Taiwan. In Penghu Islands, Magong Island is the largest island (67.14 km^2), followed by Hsiyu (18.71 km^2) and Baisha (13.88 km^2). Although it is situated in a subtropical monsoon climate and surrounded by the ocean, the average annual rainfall is about 1000 mm due to the mountainless topography (Chen, 1953). The strong sea breeze profoundly influences the vegetation in the winter (Tsai, 2009). Furthermore, the islands have a long colonial history (Taisaku, 2020), which made the landscape treeless. Despite its

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large area, there were only two gall-inducing insects recorded in Penghu Islands. Yang et al. (2004) recorded an invasive gall wasp, *Quadrastichus erythrinae* Kim, inducing galls on *Erythrina variegata* (Fabaceae), and Hong (1997: Figs 160–161) accidentally recorded an image of galls induced on the flower head of *Pluchea indica* (Asteraceae) with no further description on gall morphology or the gall inducer.

Ficus L. (Moraceae), fig tree, is a pantropical and the most diverse genus of woody plants, comprising 735 known species worldwide (Berg et al., 2005). Fig trees have been well-known among biologists for their obligate mutualism with pollinating wasps which induce gall tissue inside syconia (Bain et al., 2015). Besides, fig trees also harbor a large amount of herbivores (Basset et al., 1997; Basset & Novotny, 1999; Yang et al., 2008; Mifsud et al., 2012), including numerous gall-inducing species (Docters van Leeuwen-Reijnvaan & Docters van Leeuwen, 1926). Among fig trees, *F. microcarpa* is widespread in East Asia and distributes in low altitude regions in Taiwan (Liao, 1996). *Ficus microcarpa* presently forms forest in several relatively high inland regions and along the coastline (Hsieh, personal observation). Although once introduced for the afforestation project in the period of Japanese rule, *F. microcarpa* is probably a native species in Penghu Islands because of evidence from early Japanese plant surveys (Tashiro, 1895a, b), and the presence of a huge standing tree which is at least 300 years old (Chen, 1953).

To generate faunistic information of gall-inducing insects on *F. microcarpa* in Penghu Islands, the first author conducted 11 field surveys from September, 2020 to February, 2021. In this paper, we report insect galls that were newly recorded in these surveys.

Materials and methods

Insect galls on *F. microcarpa* were collected from Magong Island, Baisha Island and Xiyu Island from September 2020 to February 2021. The host plant, dates of collecting, locations, gall-bearing plant organs, and gall external morphology were recorded as collecting information. Plant branches with galls were cut, placed in polyethylene bags and transported to the laboratory. Samples of some galls were dissected and the developmental stages of the gall inducer was documented. Full-grown larvae and pupae were taken and preserved in 70% ethanol for further morphological examination. Samples of galls from the same collecting event at each site were identified by a lot number based on the date of collection where "TR20201024-YTH01" refers to the name of the database (TR for collecting database), the date of collecting (20201024 for 24 October, 2020), the name of collector (YTH for the first author), and the sequential number of lot (01 for the first collecting lot on 24 October, 2020). For rearing of the gall inducer, each sample of galls was transferred to a new polyethylene bag (350 by 250 mm) in the laboratory as a rearing lot, containing wet tissue paper to keep the moisture. Rearing bags were kept at room temperature, checked once a day to obtain adults of gall inducers. Once adults emerged, they were picked out with ethanol-moistened tweezers and transferred to a vial of 70% ethanol. Rearing lots follow a similar system as collecting lots, where "Rr20201024-YTH01" refers to the name of the database (Rr for rearing database), the beginning date of rearing (20201024 for 24 October, 2020), the name of rearer (YTH for the first author), and the sequential number of lot (01 for the first rearing lot on 24 October, 2020). A rearing lot number should always follow a collecting lot number to indicate the information of collection. All wild photos were recorded with a digital camera (Nikon Coolpix P7700), and archived following lot numbers.

Galls were classified into morphotypes using the host plant species, organ of occurrence, and the external morphology (shape, color, pubescence and size). For gall shape description, we followed the nomenclature of the insect gall morphospecies standardized and proposed by Isaías et al. (2013) and Isaías et al. (2014), then compared descriptions in the literature, and only created new shapes when there was no similar adjective term. Gall inducers were identified using the insect gall literature from East Asia (e.g., Yukawa & Masuda, 1996; Chen & Qiao, 2012; Tung et al., 2018). In the results reported here, galls were arranged according to the order of plant families and the taxon of the host plant. Entries for each gall were arranged in the following order: (1) galled organ and the taxon of the gall-inducing insect, if identifiable, (2) Chinese common name of the gall inducer, (3) gall shape description, (4) known distribution records with literature citation, if any, (5) voucher specimen data, and (6) Remarks, if any. For the specimen data, a double slash (//) was used to denote the line breaks on labels, while supplementary data (which may not be written on the labels, themselves) were presented in square brackets ([]). Voucher specimens were deposited in NCHU (National Chung Hsing University, Taichung, Taiwan) and YTHc (You-Ting Hsieh, private collection, Pingtung, Taiwan).

Results

New insect galls found on the Penghu Islands

MORACEAE

Ficus microcarpa L. f.

1. Leaf gall induced by *Horidiplosis* sp. (Diptera: Cecidomyiidae) (Figs 1A, 2A)

Chinese common name: 榕葉癭蚋

Gall shape: Lenticular.

Known distribution records: Penghu Islands, Taiwan (present study)

Voucher specimen data: 5♀♀ (Rr20201017-01 from TR20201017-01): collected from Aimen Beach (隘門沙灘), Penghu Co., Taiwan, 17-X-2020, leg. Y. T. Hsieh, emerged between 30-X-2020–31-X-2020 (NCHU); 1♂1♀ (Rr20201024-04 from TR20201024-01): collected from Aimen Beach (隘門沙灘), Penghu Co., Taiwan, 24-X-2020, leg. Y. T. Hsieh, emerged on 08-XI-2020 (NCHU); 10♀♀ (Rr20201115-YTH02 from TR20201115-YTH01): collected from Magoon (馬公), Penghu Co., Taiwan, 15-XI-2020, leg. Y. T. Hsieh, emerged between 02-XII-2020–11-XII-2020 (NCHU).

Remarks: The gall morphotype is similar to galls induced by *H. ficifolii* Harris which was described based on specimens reared from another common glasshouse fig tree, *Ficus benjamina* L. (Harris & Goffau, 2003), but further found to infect *F. microcarpa* (Steck & Krueger, 2008). *Horidiplosis ficifolii* was first detected on fig trees imported from Southeastern Asia (Taiwan, Japan, and China) to the Netherlands and the UK, and later reported in Italy (Suma et al., 2007), USA (Florida) (Steck & Krueger, 2008), and Czech Republic (Beránek & Šafránková, 2010). Further examination on specimens of this *Horidiplosis* species is needed to clarify its species identity.

Besides, although *H. ficifolii* has been intercepted in Europe on leaves of *Ficus benjamina* L. exported from Taiwan (Harris & Goffau, 2003), whether the species occurs in main Taiwan is still questionable due to the imprecise location of those original samples.

2. Flower gall induced by an unidentified cecidomyiid (Diptera: Cecidomyiidae) (Figs 1B, 2B)

Chinese common name: 榕果癭蚋

Gall shape: Crown-like ridge outside the syconia (cf. Yafuso et al., 2013).

Known distribution records: Penghu Islands, Taiwan (present study)

Voucher specimen data: Galls (TR20201024-01): collected from Aimen Beach (隘門沙灘), Penghu Co., Taiwan, 24-X-2020, leg. Y. T. Hsieh (NCHU); 10♂♂17♀♀ (Rr20201024-01, TR20201024-01): collected from Aimen Beach (隘門沙灘), Penghu Co., Taiwan, 24-X-2020, leg. Y. T. Hsieh, emerged between 24-X-2020–26-X-2020 (NCHU).

Remarks: This gall morphotype was induced in the syconia, causing abnormal growth outside. Similar morphotypes were recorded to be induced by *Ficiomyia perarticulata* Felt on *Ficus citriflora* Miller in Florida, USA (Roskam & Nadel, 1990), by unidentified species on *Ficus benjamina* L. in Xishuangbanna, China (Bai et al., 2008; Miao et al., 2011), and by other unidentified species on *Ficus microcarpa* L. in Okinawa and Amami, Japan (Yafuso et al., 2013).

3. Shoot gall induced by *Macrohomotoma gladiata* Kuwayama (Hemiptera: Carsidaridae) (Figs 1C, 2C)

Chinese common name: 高背木蝨

Gall shape: Rosette.

Known distribution records: China, Japan (Ryukyu island), Malaysia, Taiwan (including Penghu Islands, present study); introduced into Algeria, Morocco, Tunisia, Italy, Montenegro, Spain, USA (California, Hawaii) (Yang, 1984; Li, 2011; Pedata et al., 2012; Rung, 2016; Radonjić & Hrnčić, 2017; Burckhardt et al., 2018; Afechtal et al., 2021; Harbi et al., 2021).

Voucher specimen data: 5♂♂1♀, 9 larvae (Rr20201024-02 from TR20201024-01): collected from Aimen Beach (隘門沙灘), Penghu Co., Taiwan, 24-X-2020, leg. Y. T. Hsieh, emerged between 25-X-2020–28-X-2020 (NCHU); 2♀♀, 7 larvae (Rr20201121-YTH04 from TR20201121-YTH03): collected from Waian (外垵), Penghu Co., Taiwan, 21-XI-2020, leg. Y. T. Hsieh, emerged between 22-XI-2020–23-XI-2020 (NCHU).

Remarks: Some galls were only recorded with photos at Magong Ancient Castle (媽宮古城), Penghu Co., Taiwan (on 21-XI-2020, leg. Y. T. Hsieh, Rr20201115-YTH03 from TR20201115-YTH03). This species originated in the oriental region and was introduced to Europe, North America and northern Africa over the past ten years. Its host plant has been widely planted as ornamental plants and eggs hide in new leaf buds that make them quite cryptic in the early stage. Therefore, *M. gladiata* may be easily transferred artificially via its host plant. In the native region, *M. gladiata* is generally not considered as a serious pest. However, in an invasive region, the infestation of *M. gladiata* on *F. microcarpa* would be much more severe and needs chemical control.

4. Shoot gall induced by *Gynaikothrips* sp. (Thysanoptera: Phlaeothripidae) (Figs 1D, 2D)

Chinese common name: 榕薊馬、榕管薊馬、榕癭薊馬

Gall shape: Marginal roll.

Known distribution records: The two candidate species were introduced from Southeast Asia, and spread throughout the tropics and subtropics where the host plant cultivated (Mound et al., 1995; Held et al., 2005).

Voucher specimen data: Galls and 2 adults (Rr20201115-YTH04 from TR20201115-YTH01): collected from Magoon (馬公), Penghu Co., Taiwan, 15-XI-2020, leg. Y. T. Hsieh (YTHc); Galls and 1 adult (Rr20201115-YTH05 from TR20201115-YTH03): collected from Magong Ancient Castle (媽宮古城), Penghu Co., Taiwan, 15-XI-2020, leg. Y. T. Hsieh (YTHc); Galls and 2 adults (Rr20201121-YTH03 from TR20201121-YTH03): collected from Waian (外垵), Penghu Co., Taiwan, 21-XI-2020, leg. Y. T. Hsieh (YTHc).

Remarks: Two congeneric species of the genus *Gynaikothrips*, *G. ficorum* (Marchel) and *G. uzeli* Zimmermann, induce leaf rolling galls on *Ficus* spp. and have been reported in main Taiwan (Mound et al., 1995; Wang & Lin, 2020). The distinction of these two species is debated because of inconspicuous morphological difference (Mound et al., 1995; Mound & Marullo, 1996; Wang & Lin, 2020; Mound & Tree, 2021), but two names are still retained and followed here for the convenience of future studies. Though the two species often coexist in the same gall on both *F. microcarpa* and *F. benjamina* L. (Tree et al., 2015), host specificity experiments showed that *G. ficorum* could only initiate the formation of galls on *F. microcarpa* (Tree et al., 2015; Arthurs et al., 2016). However, our observation in Penghu was somehow not consistent with Tree et al. (2015) and Arthurs et al. (2016). During our surveys, *G. ficorum* was only presented in one of our collections with the coexistence of *G. uzeli* (Rr20201115-YTH04 from TR20201115-YTH01), while *G. uzeli* presents alone in all other collections. Tree & Walter (2009) found adults of *Gynaikothrips* species could move between galls freely, therefore non-inducer species might occasionally enter galls of other gall-inducing species, even after the leaving of gall inducers. Despite studies in the literature, we highly suggest further careful observation about the gall-inducing habit in the wild is needed to clarify the true gall inducer of this morphotype.

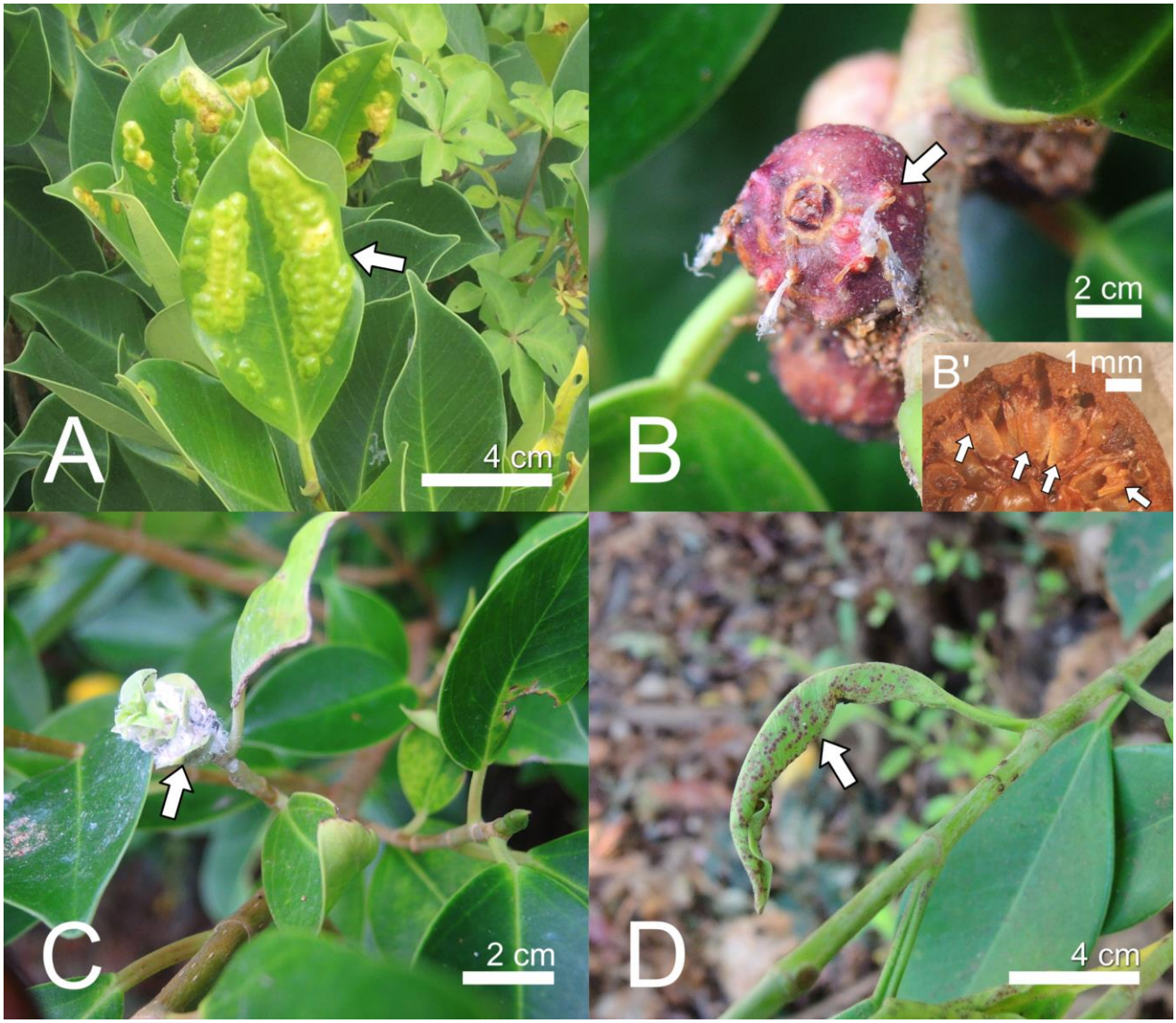

Figure 1. Gall morphotypes of *Ficus microcarpa* in Penghu Islands. A, lenticular galls on leaves; B, crown-like ridges outside the syconia; B', flower galls inside the syconia; C, a rosette gall on a shoot; D, a marginal roll gall on a leaf. Arrows indicate the locations of galls.

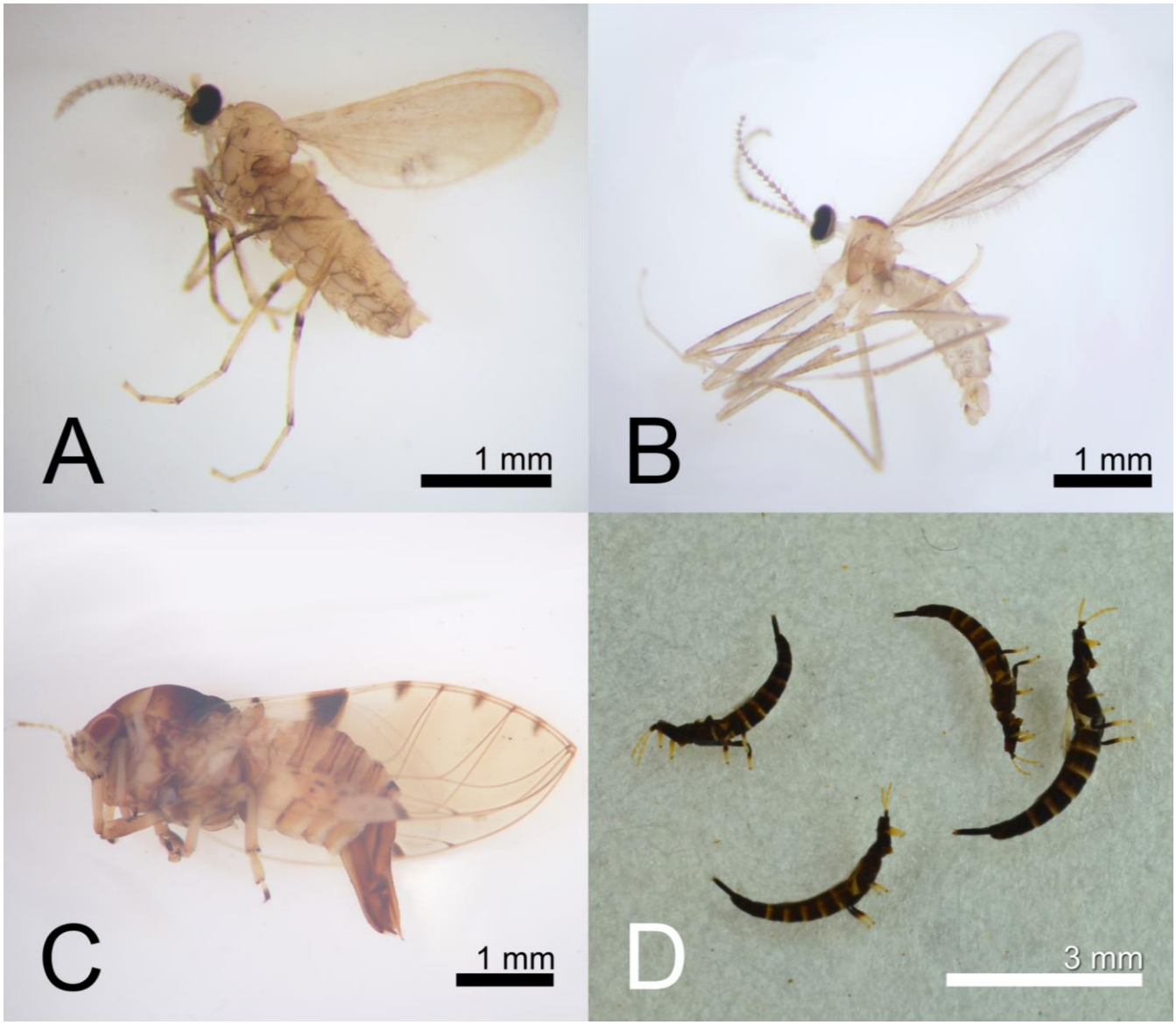

Figure 2. Habitus of the gall inducer of each gall morphotypes on *Ficus microcarpa* in Penghu Islands. A, Male *Horidiplosis* sp.; B, Male Cecidomyiidae *unid.* sp.; C, Female *Macrohomotoma gladiata*; D, An adult and larvae of *Gynaikothrips uzeli*.

Discussion

Ficus microcarpa has been reported as a host of several gall-inducing insects, e.g. cecidomyiids (Steck & Krueger, 2008; Yafuso et al., 2013), psyllids (Hollis & Broomfield, 1989), and thrips (Mound et al., 1995). In Penghu Islands, the gall-inducing insect fauna on *F. microcarpa* hasn't been recorded before. In this study, a total of 4 gall morphotypes were newly recorded in the islands. More than that, since *F. microcarpa* in Penghu Islands was able to regenerate (Hsieh, personal observation), thus it should host its mutual pollinating wasp to be pollinated. *Eupristina verticillata* Waterston, the mainly pollinating wasp of *F. microcarpa* which inducing flower galls in the syconia (Chen et al., 1999; Bain et al., 2015), should logically occur in the Islands. The gall-inducing insects on *F. microcarpa* in the Penghu Islands tentatively totals 5 species. It should be noted that our surveys didn't cover the whole growing season, e.g. in spring and summer. Further investigation is suggested to be conducted in these seasons.

Penghu Islands are of volcanic origin, and the flora and fauna of islands were deduced to originate from neighboring regions (Carlquist, 1974). The gall-inducing habit makes the host-shifting event less frequent compared to other non-gall-inducing herbivores, because gall-inducing insects are tightly associated with their host plants (Yukawa & Uechi, 1999). This suggests that gall-inducing insects might colonize the islands with the introduction of their host plants. Wang et al. (2007) showed that the flora of Penghu Islands was most similar to Taiwan island and mainland China, which implies the two possible sources of its gall-inducing insect fauna. In this study, a total of 4 gall-inducing insects were found in Penghu Islands. Two of them, *M. gladiata* and *Gynaikothrips* sp., occur in both mainland China (Mound et al., 1995; Held et al., 2005; Li, 2011) and Taiwan Island (Tung et al., 2018), although it is still unknown whether the *Horidiplosis* fig cecidomyiid (Fig. 2A) and the unidentified species (Fig. 2B) are also distributed in both regions. From another aspect, gall-inducing insects are highly likely to be introduced and successfully

establish due to extensive introduction of their host plants from native regions (Csóka et al., 2017). It was recorded that the colonial government once exported nursery trees of *F. microcarpa* from Hengchun (恆春) township of southern Taiwan to Penghu in 1911 for the afforestation project (Taisaku, 2020). The gall-inducing insects on *F. microcarpa* in Penghu Islands might accidentally be introduced due to the import of nursery trees. This "Introduced from Taiwan Island by importing nursery trees" hypothesis could be tested by further works using molecular phylogenetic methods and DNA haplotypes.

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臺灣澎湖群島產正榕之蟲癭的首次報導

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摘要: 蟲癭型式多數與其造癭者具有種間對應的關係，因此透過蟲癭形態種的調查，研究者可以初步判斷一地區的造癭昆蟲相。澎湖群島是臺灣最大的離島群，然而目前並不瞭解島上的造癭昆蟲相。在本研究中，我們選擇於澎湖群島廣布的正榕 (*Ficus microcarpa* L.) 作為造癭昆蟲相調查的目標。我們於西元 2020 年 9 月至西元 2021 年 2 月，針對馬公島、白沙島及西嶼島生長之正榕，進行蟲癭的採集。研究結果共新增 4 種蟲癭形態種於澎湖地區的紀錄，造癭昆蟲類群包含癭蚋 (雙翅目：癭蚋科) 2 形態種 (*Horidiplosis* sp. 及一未鑑定物種)、高背木蝨 (*Macrohomotoma gladiata* Kuwayama) (半翅目：錦葵木蝨科)，及榕母管薊馬屬 (*Gynaikothrips* sp.) (纓翅目：管薊馬科) 1 形態種。我們就現有標本討論了各形態種的分類地位。澎湖群島產正榕上的造癭昆蟲可能由鄰近區域 (如中國及臺灣) 天然擴散而來，但亦可能隨著 1910 年代因為造林目的而輸入的樹苗，自臺灣南部引入。進一步透過分子生物學研究，將可協助釐清澎湖群島產正榕上造癭昆蟲的來源。

關鍵詞: 癭蚋科、錦葵木蝨科、母管薊馬屬、原生植物

[研究文章 Research Article]

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First Record of *Ozola japonica* Prout, 1910 (Lepidoptera: Geometridae: Desmobathrinae) from Taiwan, and a Preliminary Conservation Assessment of its Yangmingshan Population

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Abstract. The study provides the first record of the geometrid species *Ozola japonica* Prout, 1910 from Taiwan, based on specimens from a single population in the Yangmingshan region. Based on this restricted known distribution, a preliminary assessment of conservation potential for this population is also provided.

Key words: Fauna, continental island, Oriental region, *Premna*, Lamiaceae

Introduction

The desmobathrine genus *Ozola* Walker, 1861 is widely distributed in the Old World, and is represented by about 30 species in the Oriental region (Holloway, 1996; Yazaki, 2019). Hitherto represented in Taiwan by a single species, *O. defectata* Inoue, 1971 (Inoue, 1992), the present study provides the first record of an additional *Ozola* species, and raises potential conservation issues associated with its apparently restricted distribution.

Materials and methods

Specimens from the following institutions were either loaned or examined on site:

NSMT – National Science Museum, Tsukuba (previously Tokyo).

TFRI – Insect collection of Taiwan Forestry Research Institute, Taipei.

Genitalia preparations for morphological studies

Genitalia were prepared following the method described by Holloway et al. (1987), with the following modifications: After maceration of the abdomen in 10% KOH and subsequent cleaning, male genitalia were carefully removed from the abdomen and abdominal segments 1–8 were opened along the caudocephalic axis from the right side. Female genitalia were removed entirely from the abdomen, cleaned and mounted ventral side facing upwards. All the membranous genital tubes and bursae derived from the genital openings were preserved. Genitalia and abdominal skins of both sexes were stained with pen ink (Pilot), preserved in 70% ethanol then transferred in 99.5% ethanol before mounting in Euparal on slides. Specimens were photographed using a Nikon D600 digital camera and slides were photographed using a Nikon D500 digital camera with flash.

Results

Ozola japonica Prout, 1910

日本小褐尺蛾

(Figs 1–4, 7–12)

Ozola impedita japonica Prout, 1910, *Gen. Ins.* 104: 94.

Ozola japonica: Prout, 1912–1916: 10, pl. 1f; Holloway, 1996: 164; Nakajima, 2011: 204, pl. 1-40-5, 6; Yazaki & Wang, 2018: 178, 19, 56; Yazaki, 2019: 10, figs 6, 10, 14; Kishida, 2020: 33.

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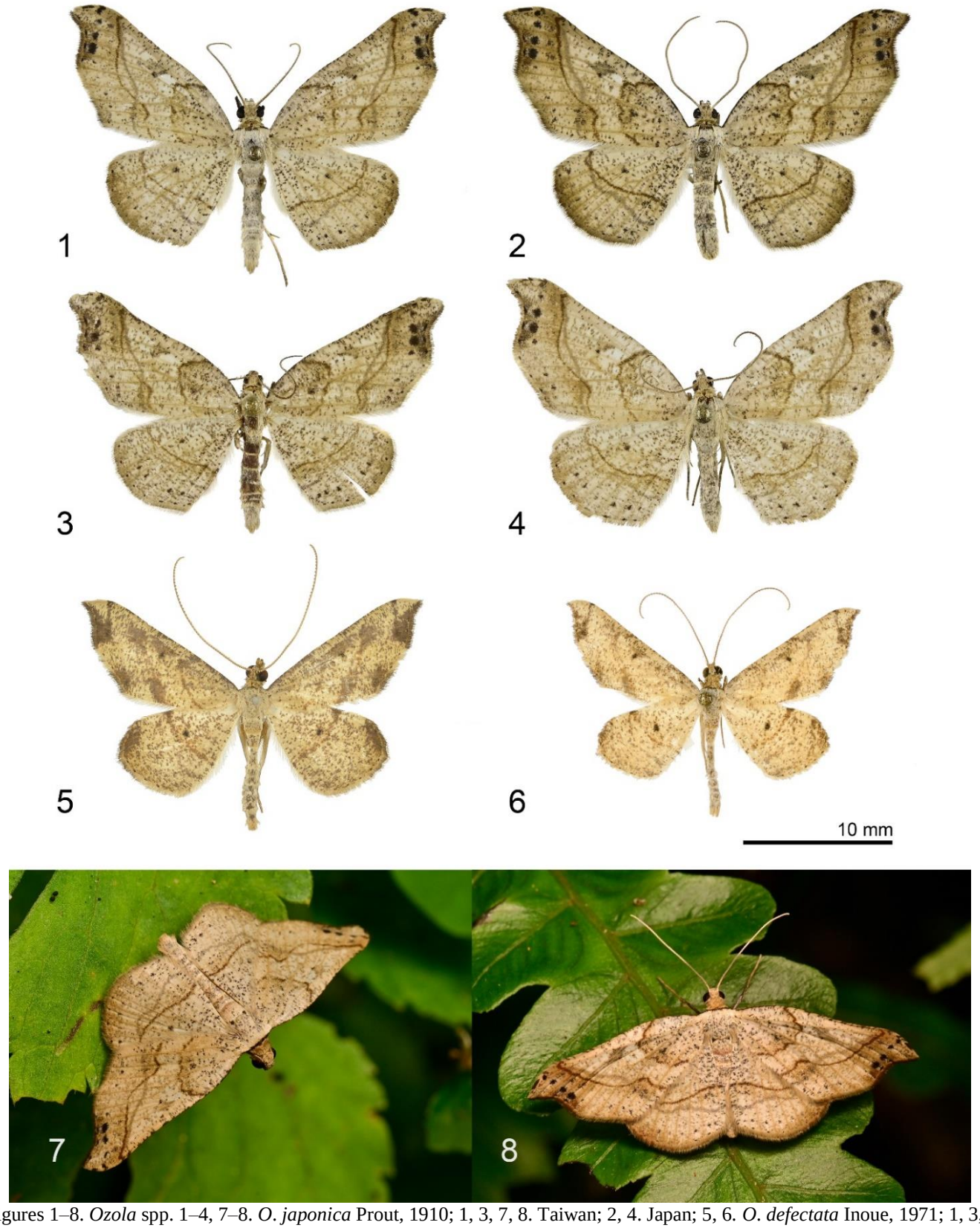
Specimens examined. JAPAN (type locality): 1♂, Nagasaki, Goto Is., Fukuejima I., Ogawara Dam, 170 m, 26. VI. 1996, leg. M. Owada, slide NSMT-SW1357♂ (NSMT); 1♀, Tsushima, Kamitsushima, Kuchinashidani Tunnel, 250 m, 3. VII. 2011, leg. M. Owada, slide NSMT1358♀ (NSMT). **TAIWAN:** Taipei City: 2♂♂2♀♀, Tamshui, Erziping, 800 m, 15-16-VI. 2021, leg. S. Wu & S. S. Wu, slide TFRI209673♂ & 209673♀ (TFRI).



Figures 1–8. *Ozola* spp. 1–4, 7–8. *O. japonica* Prout, 1910; 1, 3, 7, 8. Taiwan; 2, 4. Japan; 5, 6. *O. defectata* Inoue, 1971; 1, 3, 5, 7. Male; 2, 4, 6, 8. Female. Courtesy of specimens: TFRI (1, 2, 5, 6), NSMT (3, 4). Scale bar = 10 mm. Photo by Shipher Wu.

Taxonomic notes. Yazaki (2019) reviewed the *Ozola impedita* (Walker, 1861) group, in which he included four species, including one newly described in that paper. The Taiwanese specimen is externally similar to the other members of this group and can be identified (based on the genitalia of both sexes) as *O. japonica*, originally described in Japan by Prout (1910), and recently recorded in Nanling Mts, S. China (Yazaki & Wang, 2018). The genitalia of *O. japonica* are distinct from those of other species in *impedita* group, based on *O. japonica*'s: longer apical valval processes; broader, undulate ventrobasal valval processes, and the absence of a vesical cornutus (Figs 9, 10); the short and slender corpus bursae, with the posterior part thinly sclerotized, and bearing some stout spines (Figs 11, 12). Slight variation in the shape of apical valval process has been observed among *O.* japonica specimens from Taiwan (Fig. 9), Japan (Fig. 10), and China (see Yazaki, 2019: fig. 10).

Figures 9–12. Genitalia of *Ozola japonica* Prout, 1910. 9. Male, Taiwan (TFRI); 10. Male, Japan (NSMT); 11. Female, Taiwan (TFRI); 12. Female, Japan (NSMT). Photo by Shipher Wu.

Diagnosis. Diagnoses of species within *Ozola impedita* group should be based primarily on genitalic characters because external characters such as wing patterns can be similar among species; species in this group are also known to be allopatrically distributed (Yazaki, 2019). In Taiwan, *O. japonica* has been collected from sites above 400m in the Yangmingshan (Northern Taiwan), while *O. defectata* Inoue, 1971 (Figs 5, 6), know to occur allopatrically, is primarily distributed below 200 m in the coastal forest. *O. japonica* can be distinguished from *O. defectata* by the anterior margin of the forewing, bowing outwards slightly basomedially and straightening apically in *O. japonica*, while running almost straight throughout in *O. defectata*; by the distinct wing fasciae in *O. japonica* compared to the more indistinct darkened patched through the tornal region and medial part of inner margin.

Distribution. Japan, China (Yazaki and Wang, 2018); Taiwan (new record).

Discussion

According to Nakajima (2011), the larvae of *O. japonica* feed on *Premna microphylla* Turcz. (Lamiaceae) in Japan. While collecting at night in Erziping area of the Yangmingshan region in June, 2021, around 20 *O. japonica* individuals were observed resting within a radius of 10 meters from a *P. microphylla* individual; immature stages were not observed, likely due to phenological reasons. Chung (2018) gave the distribution of *P. microphylla* of Taiwan in the North and East of the island, however this moth species seems to be restricted in Yangminshan region, an independent mountain system of Northern Taiwan, based on 35 Citizen

Science records deposited in the database of Taiwan Moth Information Center (https://twmoth.tesri.gov.tw/, accessed 4 October 2021). In contrast, *O. defectata* Inoue, 1971 feeds on another *Premna* species, *P. serratifolia* L.; both moth and plant species are widely distributed around the coastal region based on similar numbers of Citizen Science records (about 30 records) in the same database. To the best of my best knowledge, *O. japonica* is the only case of a Taiwanese moth species being restrict to the Yangmingshan region. Further study is needed to clarify the hostplant and potential broader distribution range of *O. japonica* in Taiwan, despite *Premna microphylla* being the only representative of the genus *Premna* in this region (Huang, 1983). If this species does indeed have a relatively restricted distribution, as this study suggests, then the level of threat to this species is low for the time being because its entire distribution is within the Yangmingshan National Park.

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日本小褐尺蛾的臺灣首次紀錄以及對其陽明山族群的初步保育評估（鱗翅目：尺蛾科：細尺蛾亞科）

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摘要: 本研究首次記錄尺蛾類群的日本小褐尺蛾 (*Ozola japonica* Prout, 1910) 在臺灣的分布。由於本種在臺灣已知的分布僅限於陽明山山區，因此對此族群作初步的保育評估。

關鍵詞: 生物相、大陸型島嶼、東方區、魚臭木屬、唇形科

[研究文章 Research Article]

http://zoobank.org/urn:lsid:zoobank.org:pub:D31ABC88-6E93-4035-9DC1-DEDC09EE3A56

臺灣產蠟蟬總科之科級鑑定（半翅目：頸喙亞目）

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摘要: 本文針對臺灣產蠟蟬總科，包含小頭飛蝨科、短翅飛蝨科、菱飛蝨科、稻蝨科、長翅飛蝨科、象蠟蟬科、蛾蠟蟬科、蠟蟬科、圓飛蝨科、粗腳飛蝨科、縞飛蝨科、脊唇蠟蟬科、廣翅蠟蟬科及軍配飛蝨科等 14 個科，提供各科的簡介及符合當前高階分類系統的成蟲科級圖索表。

關鍵詞: 蠟蟬下目、科、檢索表、高階分類系統

前言

蠟蟬總科 (Fulgoroidea) 為半翅目 (Hemiptera) 頸喙亞目 (Auchenorryncha) 底下的一個總科，由 21 個現生的科及至少 15 個已滅絕的科所組成 (Bourgoin, 2021)，其成員即為廣義的「蠟蟬 (planthoppers)」。外部形態上可藉由觸角著生於複眼下方、梗節膨大且分布瓦楞感覺器 (sensory plaque organs) 等特徵，與其他總科昆蟲區辨 (Shih & Yang, 1996; Bartlett et al., 2014)。蠟蟬總科地理分布廣泛，範圍涵蓋熱帶、亞熱帶、溫帶，甚至寒帶地區，已知種類皆棲息於陸域環境。成蟲皆為植食性，部分種類為農作物經濟重要性害蟲，為害方式主要以刺吸式口器吸食植物韌皮部汁液，某些種類為植物病毒、細菌與植物菌質體等病原的媒介昆蟲 (Bartlett et al., 2014)。其排泄物中因含大量的碳水化合物，被排泄物分布所及的植物組織表面成為真菌孢子的天然培養基，造成煤煙病，此為間接性危害 (Chou et al., 1985)。儘管蠟蟬總科中包含一些可造成經濟損害的農業害蟲，亦有不少種類因外型美麗深受業餘昆蟲同好與生態攝影者青睞。自二十世紀末以來，蠟蟬總科的高階分類系統發生了許多變動，其中又以圓飛蝨科 (Issidae) 的組成變化最大，例如：Emeljanov (1999) 將圓飛蝨科的短翅飛蝨亞科 (Caliscelinae) 提升為獨立的科，而在剩餘的圓飛蝨物種中，Tongini 族的成員則被轉移至峻翅蠟蟬科 (Acanaloniidae)，後來又被 Gnezdilov (2007) 轉移至脊唇蠟蟬科 (Nogodinidae)。目前，蠟蟬總科在臺灣共被記錄 15 個科，本文針對臺灣 14 個已被記錄的科進行簡介 (殘管蠟蟬科 (Kinnaridae) 由於缺乏可靠紀錄而未被納入)，並提供各科代表性物種之標本照，以及符合當前高階分類系統 (Bourgoin, 2021) 且適用於臺灣產種類的科級檢索表，提供非專家讀者判別蠟蟬總科各科成員的工具，同時增進大眾對本類群的認識，更期望本文能對植物保護工作者有所助益。

材料與方法

本研究檢視材料皆來自國立臺灣大學昆蟲學系昆蟲標本館 (National Taiwan University, Taiwan) 之館藏標本。標本相片以 Canon 800D 數位單眼相機搭配下列鏡頭拍攝：大型種類 (體長大於 2 cm 者) 搭配 Contax Carl Zeiss S-Planar 60mm F2.8 AEG 鏡頭；中小型種類 (體長約當或小於 2 cm 者) 及細部特徵搭配 Canon MP-E 65mm F2.8 1-5X 鏡頭。檢索表改寫自 Bartlett et al. (2014) 、Chou et al. (1985) 以及 Fletcher (1999)。形態特徵術語參考 Hsu & Lin (2014) 第二章節。

結果

臺灣產蠟蟬總科成蟲科級檢索表
A Key to Adults for Families of Fulgoroidea from Taiwan

1. 後足脛節末端具一根明顯且可活動的距 (圖 1)
   Hind tibiae with a distinct movable spur at apex (Fig. 1)….....…稻蝨科 Delphacidae
   後足脛節末端不具可活動的距 (圖 2)
   Hind tibiae without a movable spur at apex (Fig. 2)…….....….....2

2. 前翅短，無法完全覆蓋腹部 (圖 3)
   Brachypterous, forewings not completely covering abdomen (Fig. 3).....….....短翅飛蝨科 Caliscelidae
   前翅可完全覆蓋腹部 (圖 4)
   Forewings covering all of abdomen (Fig. 4)…….....……..…3

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3. 後足第二跗節腹面末端不具小刺 (圖 5) 或僅具兩根小刺 (圖 6)
Ventral of second hind tarsomere without apical spines (Fig. 5) or with only two apical spines (Fig. 6).....4
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前翅膜質 (圖 13)
Forewings membranous (Fig. 13).....8

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Forewings subovate (Figs 10–11).....圓飛蝨科 Issidae
前翅不呈近橢圓形 (圖 12)
Forewings not subovate (Fig. 12).....脊唇蠟蟬科 Nogodinidae (Tribe Tongini)

8. 前額具兩條縱脊 (圖 14)
Frons with two longitudinal carinae (Fig. 14).....脊唇蠟蟬科 Nogodinidae
前額不具縱脊或僅具一條縱脊 (圖 15)
Frons without longitudinal carinae or with single longitudinal carina (Fig. 15).....軍配飛蝨科 Tropiduchidae

9. 前額寬大於長 (圖 16)；前翅近三角形 (圖 18)
Frons wider than long (Fig. 16); forewings subtriangular (Fig. 18).....廣翅蠟蟬科 Ricaniidae
前額長大於寬 (圖 17)；前翅不呈近三角形 (圖 19)
Frons longer than wide (Fig. 17); forewings not subtriangular (Fig. 19).....粗腳飛蝨科 Lophopidae

10. 口器末節短，長度與寬度大略相等 (圖 20–21)
Terminal segment of rostrum short, subequal in length and width (Figs 20–21).....長翅飛蝨科 Derbidae
口器末節明顯長大於寬 (圖 22)
Terminal segment of rostrum distinctly longer than wide (Fig. 22).....11

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Claval veins of forewings with granules (Fig. 23).....縞飛蝨科 Meenoplidae
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前胸背板寬度小於 5 mm
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14. 頭部向前延伸突起 (圖 28–29)
Head prolonged forward (Figs 28–29).....象蠟蟬科 Dictyopharidae
頭部無向前延伸突起 (圖 30)
Head not prolonged forward (Fig. 30).....菱飛蝨科 Cixiidae

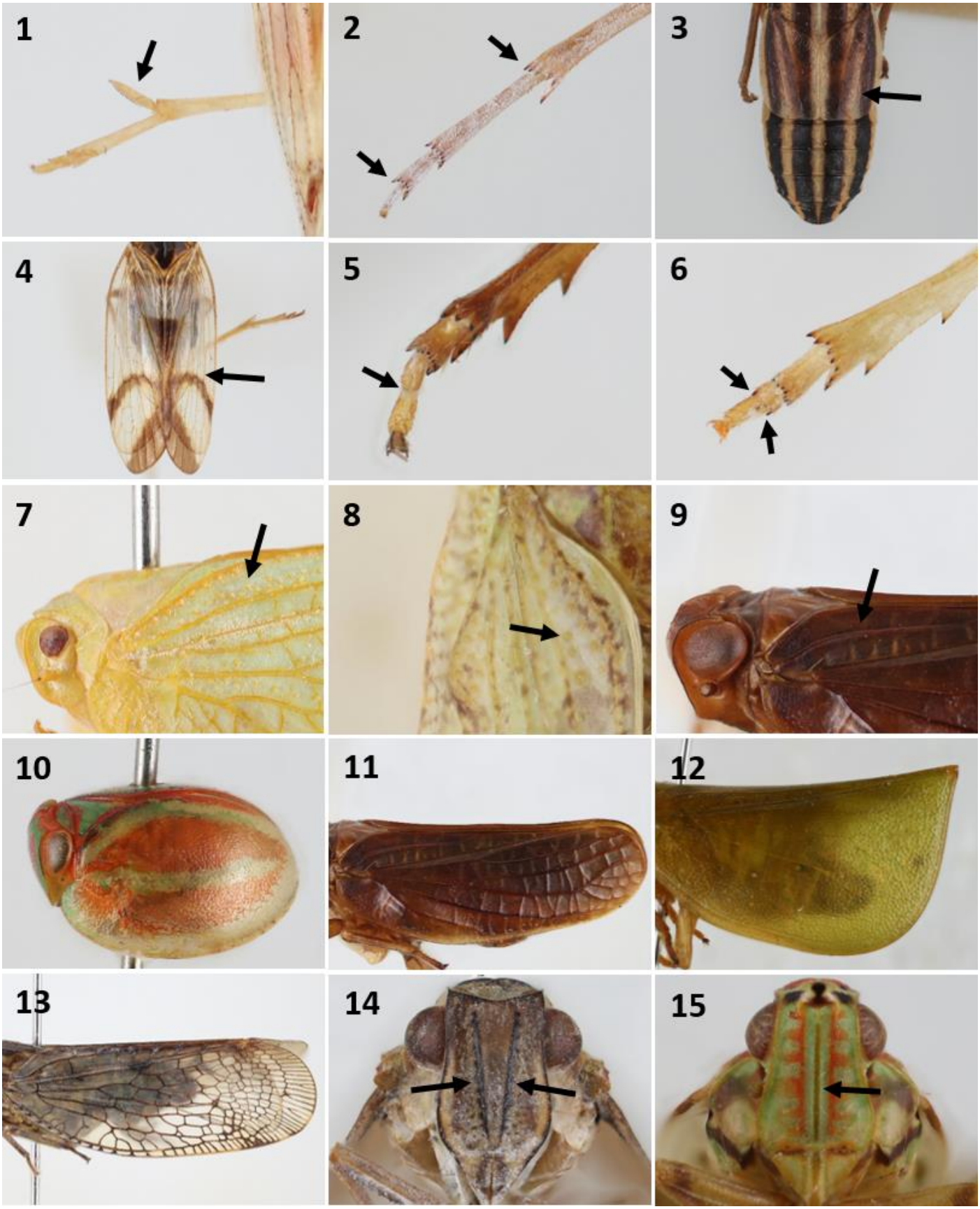

圖 1–15、蠟蟬總科分科鑑定特徵。1. 後足脛節末端具一根明顯且可活動的距 (Delphacidae)；2. 後足脛節末端不具可活動的距，第二跗節腹面末端具一列小刺 (Cixiidae)；3. 前翅短，無法完全覆蓋腹部 (Caliscelidae)；4. 前翅可完全覆蓋腹部 (Cixiidae)；5. 後足第二跗節腹面末端不具小刺 (Ricaniidae)；6. 後足第二跗節腹面末端兩側各具一根小刺 (Flatidae)；7–8. 前翅翅扇區具明顯顆粒狀突起 (Flatidae)；9. 前翅翅扇區不具明顯顆粒狀突起 (Issidae)；10–11. 前翅革質，近橢圓形

(Issidae)；12. 前翅革質，不呈近橢圓形 (Nogodinidae)；13. 前翅膜質 (Nogodinidae)；14. 前額具兩條縱脊 (Nogodinidae)；15. 前額不具縱脊或僅具一條縱脊 (Tropiduchidae)。

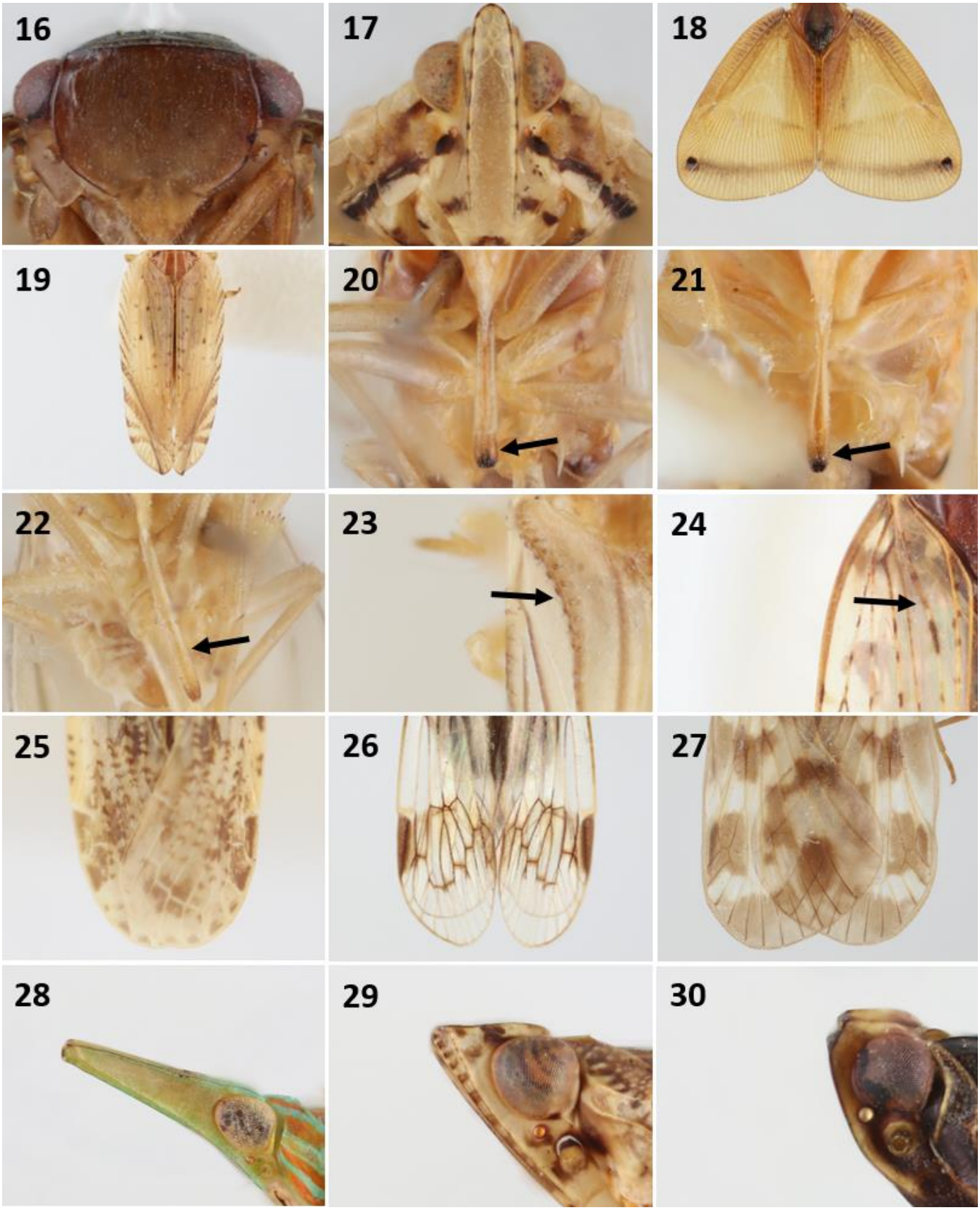

圖 16–30、蠟蟬總科分科鑑定特徵。16. 前額寬大於長 (Ricaniidae)；17. 前額長大於寬 (Lophopidae)；18. 前翅近三角形 (Ricaniidae)；19. 前翅不呈近三角形 (Lophopidae)；20–21. 口器末節短，長度與寬度大略相等 (Derbidae)；22. 口器末節明

顯長大於寬 (Meenoplidae)；23. 前翅翅扇脈上具顆粒狀突起 (Meenoplidae)；24. 前翅翅扇脈上不具顆粒狀突起 (Cixiidae)；25. 前翅收起時末端明顯重疊 (Achilidae)；26. 前翅收起時末端不重疊 (Cixiidae)；27. 前翅收起時末端部分重疊 (Cixiidae)；圖 28–29. 頭部向前延伸突起 (Dictyopharidae)；圖 30. 頭部無向前延伸突起 (Cixiidae)。

臺灣產蠟蟬總科各科簡介

1. 小頭飛蝨科 Achilidae

體小型至中型，頭小而窄，身體扁平，前翅收起時末端明顯重疊為本科之重要診斷特徵。成蟲以木本植物為食，若蟲則以真菌為食 (Bartlett et al., 2014)。

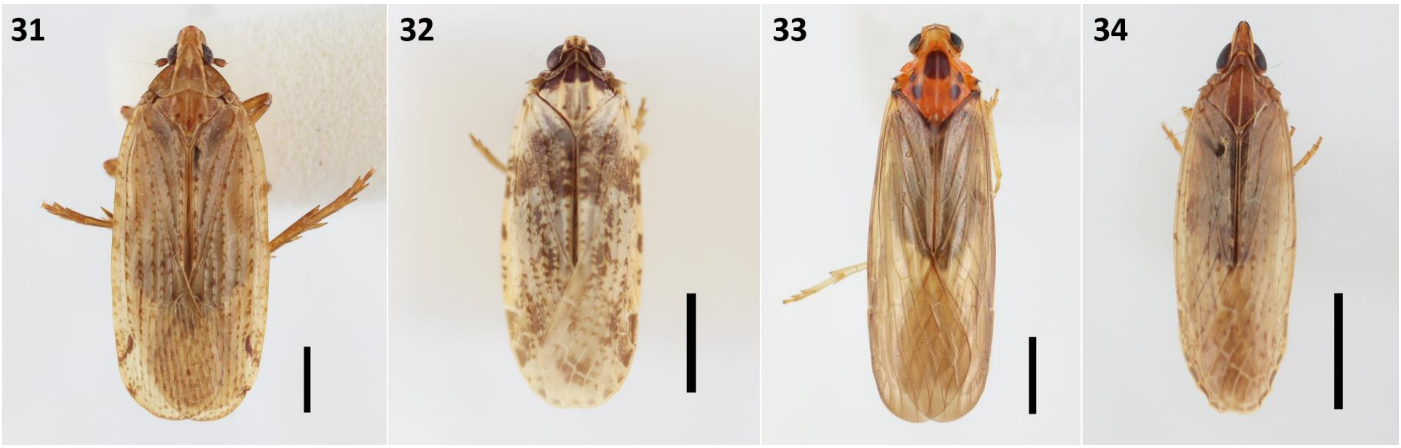

圖 31–34、小頭飛蝨科。31. *Rhotala formosana*；32. *Magadha reduncа*；33. *Kosalya improcera*；34. *Betatropis formosana*。比例尺均為 2 mm。

2. 短翅飛蝨科 Caliscelidae

體小型，臺灣產的種類前翅極短，其端緣未覆蓋腹部，後翅缺乏或退化。以草本植物為食 (Bartlett et al., 2014)。

圖 35、短翅飛蝨科，*Peltonotellus fasciatus*。比例尺為 2 mm。

3. 菱飛蟲科 Cixiidae

體小至中型，前翅透明且常有翅痣；少數種類翅不透明，前翅收起時末端部分重疊 (例如 *Borysthenes* sp.)。成蟲寄主多為木本植物，若蟲寄主則多為草本植物，少數種類會以植物的根或是真菌為食 (Bartlett et al., 2014)。本科為傳播植物菌質體病原的媒介昆蟲之一 (Bartlett et al., 2014)。

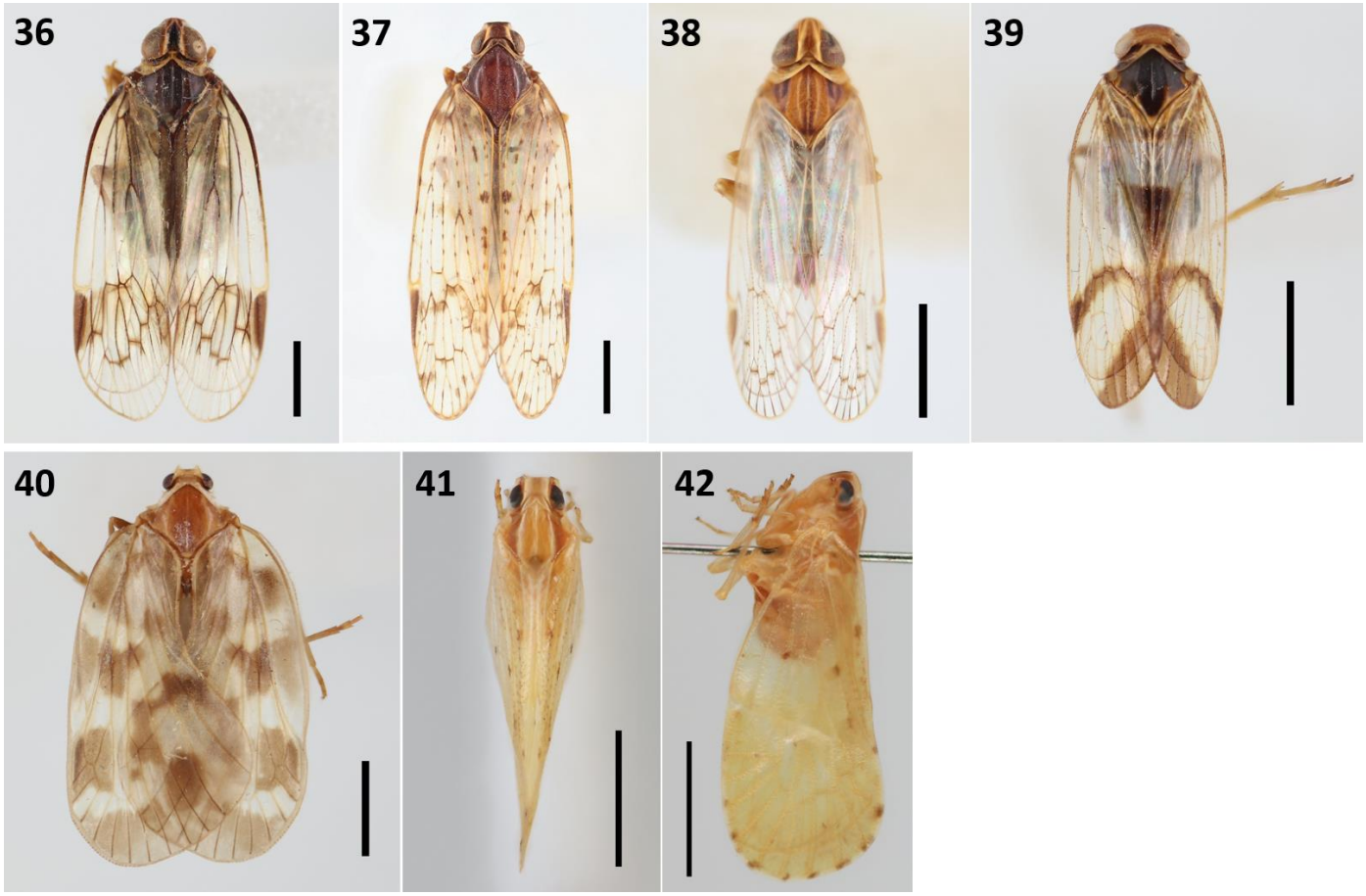

圖 36–42、菱飛蟲科。36. *Atretus horishanus*；37. *Macrocixius giganteus*；38. *Siniarus scalenus*；39. *Betacixius ocellatus*；40. *Borysthenes maculatus*；41–42. Eucarpiini sp.。比例尺均為 2 mm。

4. 稻蟲科 Delphacidae

體小至中型，許多種類觸角梗節發達呈棍棒狀，後足脛節末端具一根明顯且可活動的距為本科之重要診斷特徵，部分種類成蟲具多態型 (分為長翅型及短翅型)。本科多以單子葉植物作為寄主，部分種類可傳播植物病毒病原，為經濟重要性害蟲 (Bartlett et al., 2014)。

圖 43–46、稻蟲科。43. *Laodelphax striatellus*；44. *Yanunka incerta*；45. *Tropidocephala* sp.；46. *Ugyops* sp.。比例尺均為 2 mm。

5. 長翅飛蝨科 Derbidae

體小至中型，前翅狹長 (部分種類前翅寬廣)，口器末節特別短、長度與寬度大略相等為本科之重要診斷特徵。成蟲時常被發現於單子葉植物或枯倒木上，多數種類具有寄主專一性，若蟲以真菌為食，少數種類可傳播植物菌質體病原 (例如 *Cedusa* spp.) (Bartlett et al., 2014)。

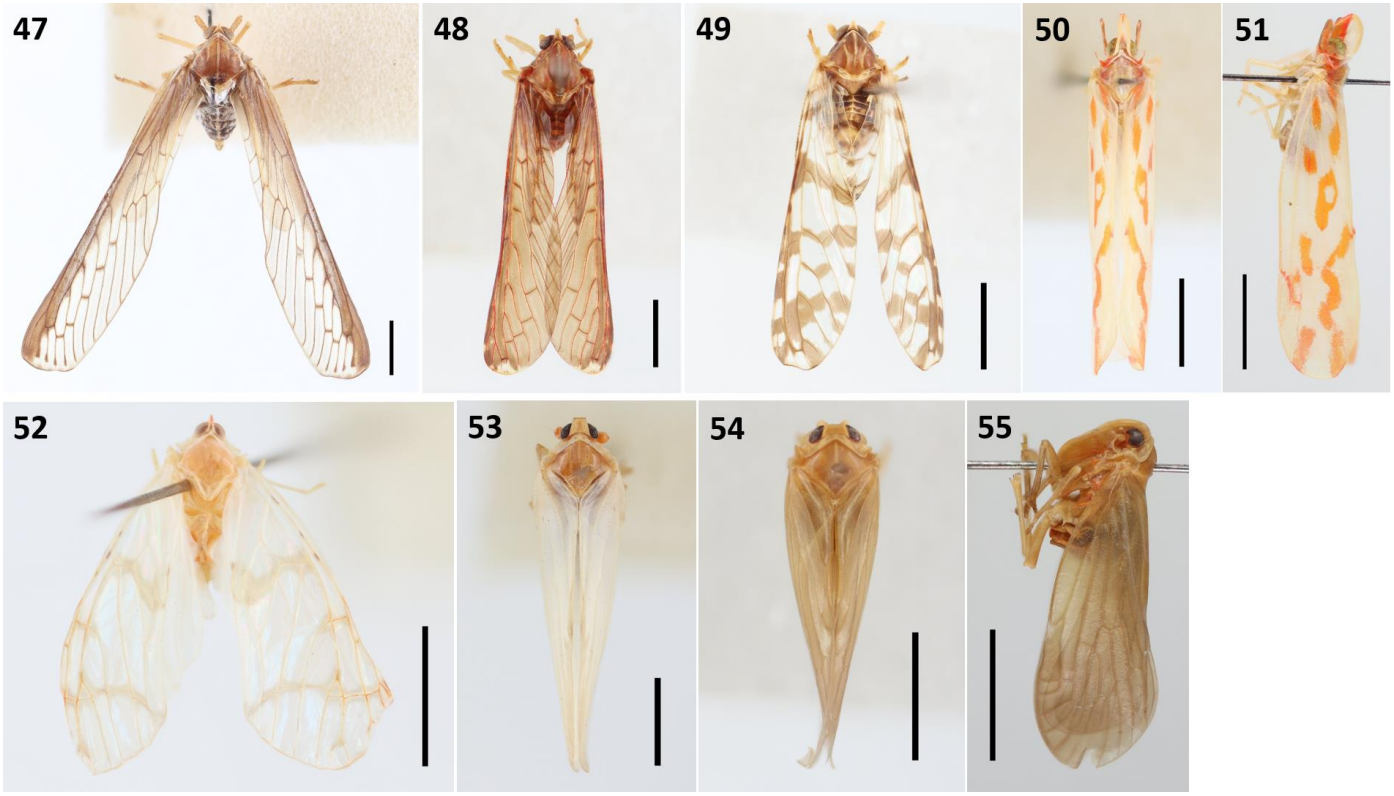

圖 47–55、長翅飛蝨科。47. *Zoraida* sp.；48. *Neoproutista pseudoalbicosta*；49. *Shizuka* sp. ；50–51. *Robigus flexuosus*；52. *Saccharodite* sp.；53. *Vekunta* sp.；54–55. *Cedusa* sp.。比例尺均為 2 mm。

6. 象蠟蟬科 Dictyopharidae

體中型，體態纖細，頭部向前延伸、不同程度的突起，翅通常透明，橫脈集中於翅端部而呈網狀，後足第二跗節腹面末端具一列小刺。多數種類以雙子葉植物作為寄主且多有寄主專一性 (Bartlett et al., 2014)。

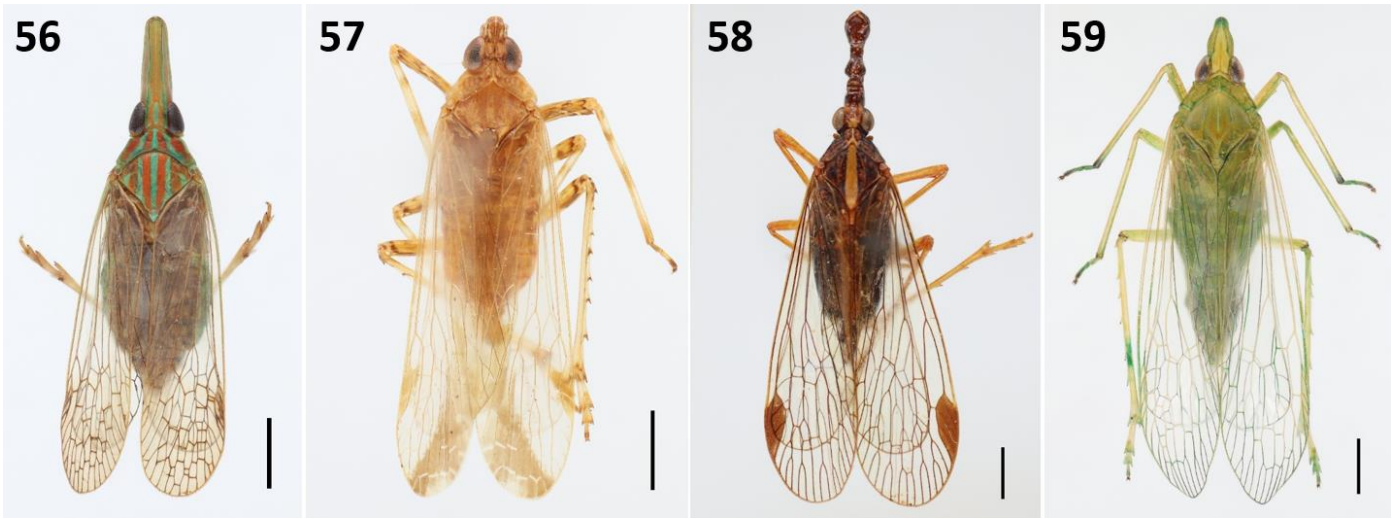

圖 56–59、象蠟蟬科。56. *Raivuna* sp.；57. *Orthopagus* sp.；58. *Saigona fulgoroides*；59. *Tenguna watanabei*。比例尺均為 2 mm。

7. 蛾蠟蟬科 Flatidae

體小至中型，外型酷似蛾類，前翅之前緣區具有許多橫脈，翅扇區具明顯顆粒狀突起，多數種類停棲時兩對翅近乎垂直地往身體兩側下斜呈「屋脊狀」，少數種類 (例如 *Atracis* spp.) 停棲時兩對翅平攤於背部。本科以木本及類木本植物為食 (Bartlett et al., 2014)。

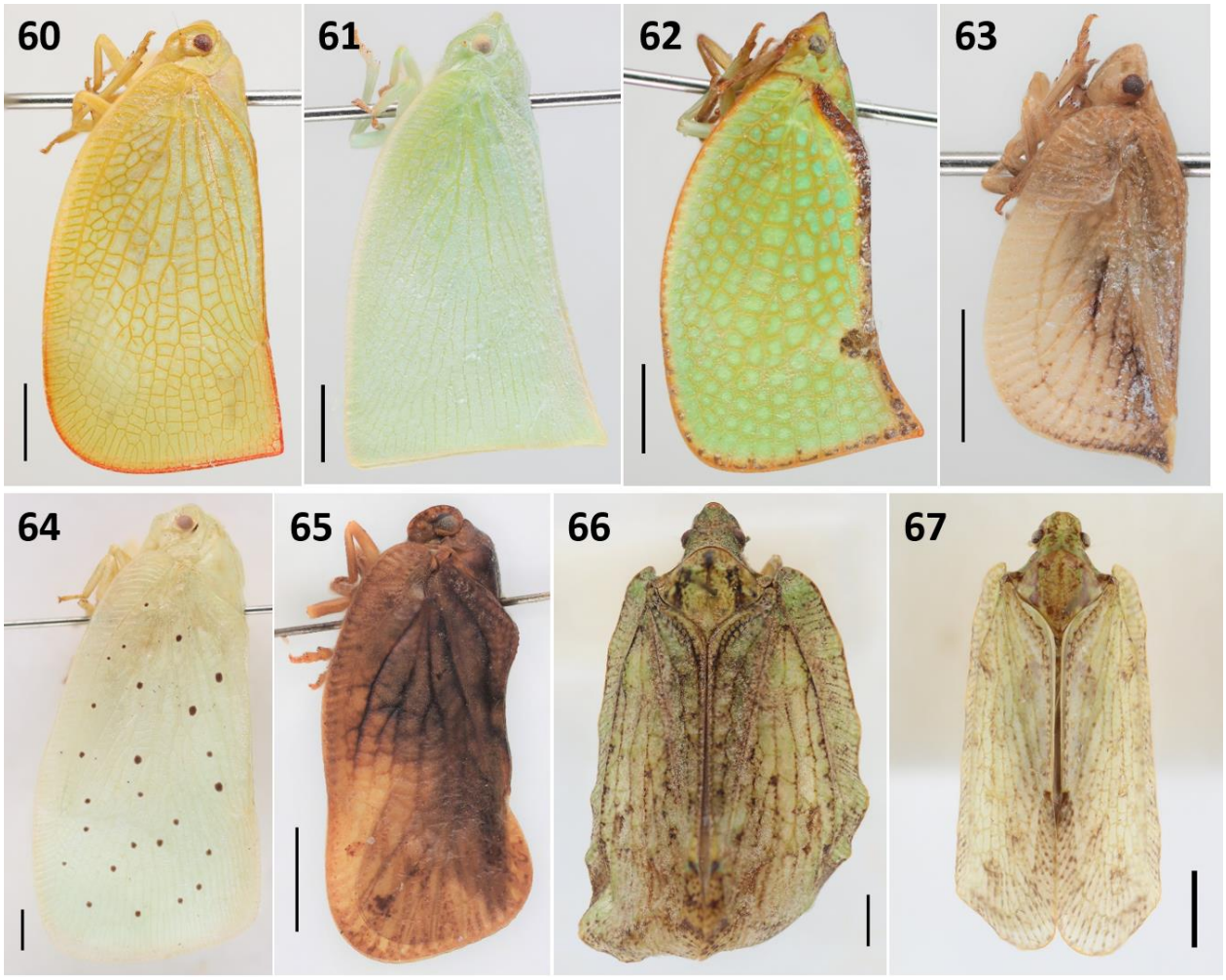

圖 60–67、蛾蠟蟬科。60. *Geisha distinctissima*；61. *Phylliana alba*；62. *Salurnis marginella*；63. *Mimophantia* sp.；64. *Flata* sp.；65. *Armorseliza lignaria*；66. *Atracis mucida*；67. *Atracis formosana*。比例尺均為 2 mm。

8. 蠟蟬科 Fulgoridae

體大型，體寬，前胸背板寬度大於 5 mm，許多種類的頭部前額向前或向上延伸突起，多數種類前翅或後翅具鮮豔色彩或斑紋，後翅臀區 (anal area) 橫脈多而呈網狀常被視為本科之診斷特徵，但亦有部分種類不具此特徵 (例如 *Dichoptera similis*)。成蟲多以木本植物為食，若蟲時期可能須仰賴多種寄主植物維生。

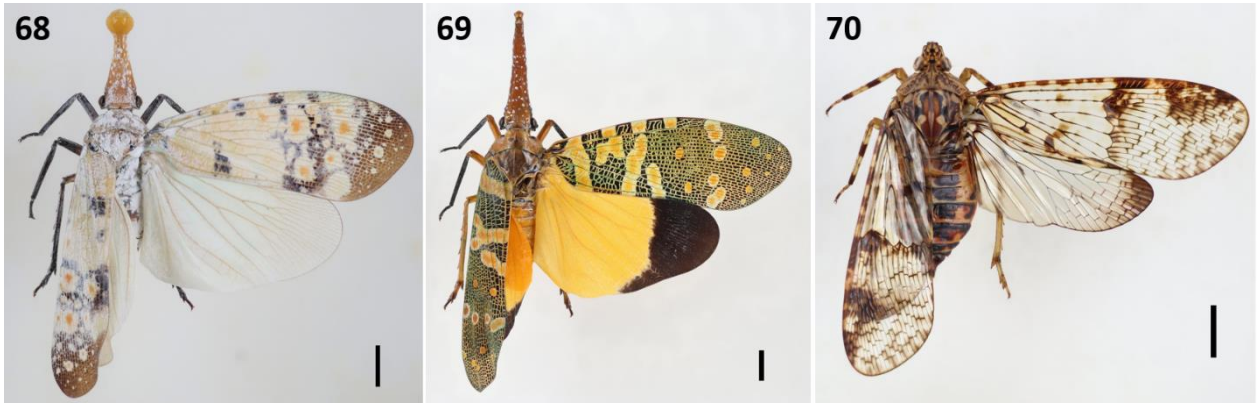

圖 68–70、蠟蟬科。68. *Pyrops watanabei*；69. *Pyrops candelaria*；70. *Dichoptera similis*。比例尺均為 5 mm。

9. 圓飛蝨科 Issidae

體小至中型，前翅革質化，近橢圓或長橢圓形，不透明，顏色單一或鮮豔，許多種類外型類似瓢蟲，後足第二跗節腹面末端兩側通常各具一根小刺，但亦有少數種類不具小刺。

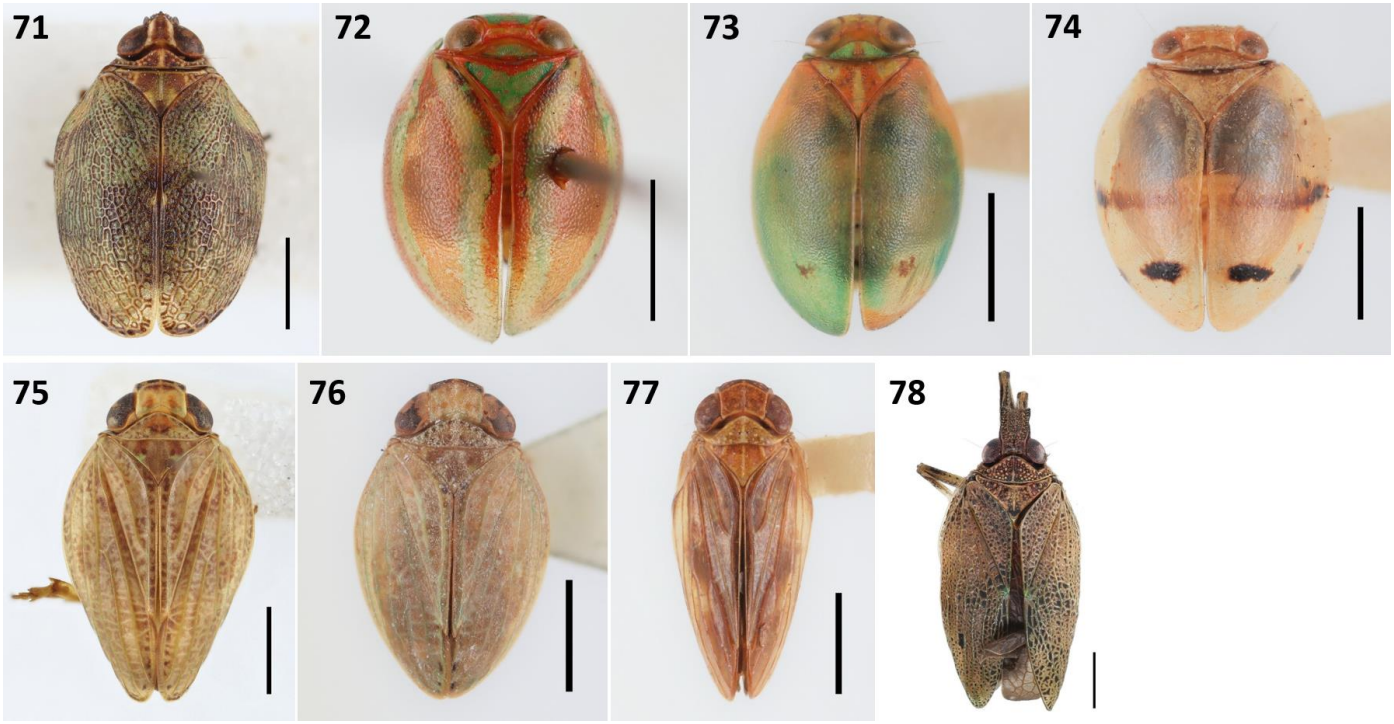

圖 71–78、圓飛蝨科。71. *Gergithoides carinatifrons*；72. *Hemisphaerius formosus*；73. *Hemisphaerius testaceus*；74. *Epyhemisphaerius bistriatus*；75. *Gelastyrella litaoensis*；76. *Thabena brunnifrons*；77. *Eusarima* sp. ；78. *Fortunia sinensis*。比例尺均為 2 mm。

10. 粗腳飛蝨科 Lophopidae

體中型，頭細窄，前額狹長 (長大於寬)，部分種類前足脛節擴大成葉狀。

圖 79、粗腳飛蝨科，*Lophops carinata*。比例尺為 2 mm。

11. 縞飛蝨科 Meenoplidae

體小型，體色白至棕黑色，頭部背面觀之前緣左右兩側略向前突出，前翅翅扇脈上具顆粒狀突起為本科重要診斷特徵，部分長翅飛蝨亦具有此特徵，但本科口器末節長度明顯大於寬度。多以草本植物為食 (Tsaur et al., 1986)。

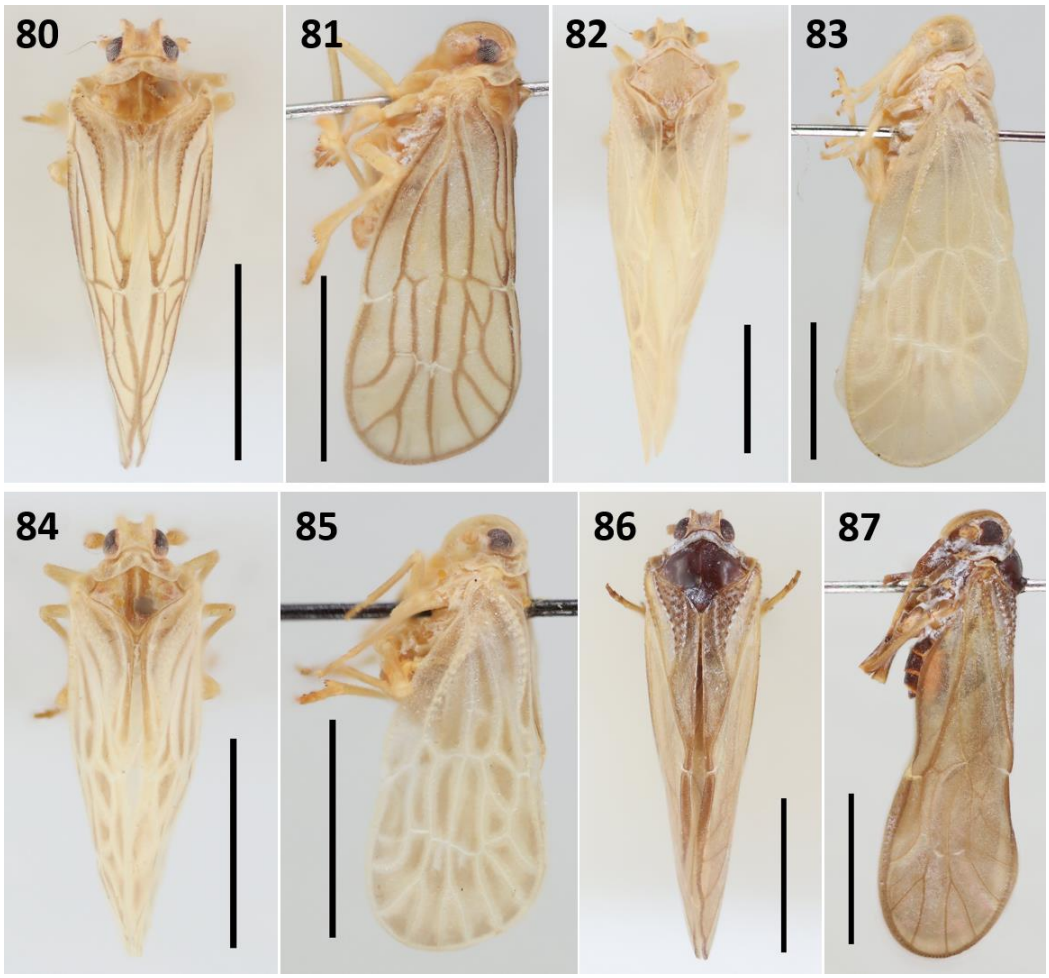

圖 80–87、縞飛蝨科。80–81. *Nisia serrata*；82–83. *Tyweponisia woodwardi*；84–85. *Eponisia guttula*；86–87. *Anigrus frequens*。比例尺均為 2 mm。

12. 脊唇蠟蟬科 Nogodinidae

體中型，典型的特徵包含頭部短，前緣由背面觀看似被截平，前額具有兩條明顯的縱脊 (經常呈「V」字形)，前翅呈膜質狀，平攤於背部；臺灣產的 Tongini 族種類前翅革質化，停棲時兩對翅近乎垂直地往身體兩側下斜呈「屋脊狀」。

圖 88–90、脊唇蠟蟬科。88. *Pisacha encaustica*；89. *Mindura subfasciata kotoshonis*；90. *Tonga westwoodi*。比例尺均為 2 mm。

13. 廣翅蠟蟬科 Ricaniidae

體小至中型，頭短而寬，前額寬廣 (寬大於長)，前翅略呈三角形，停棲時平攤於背部。

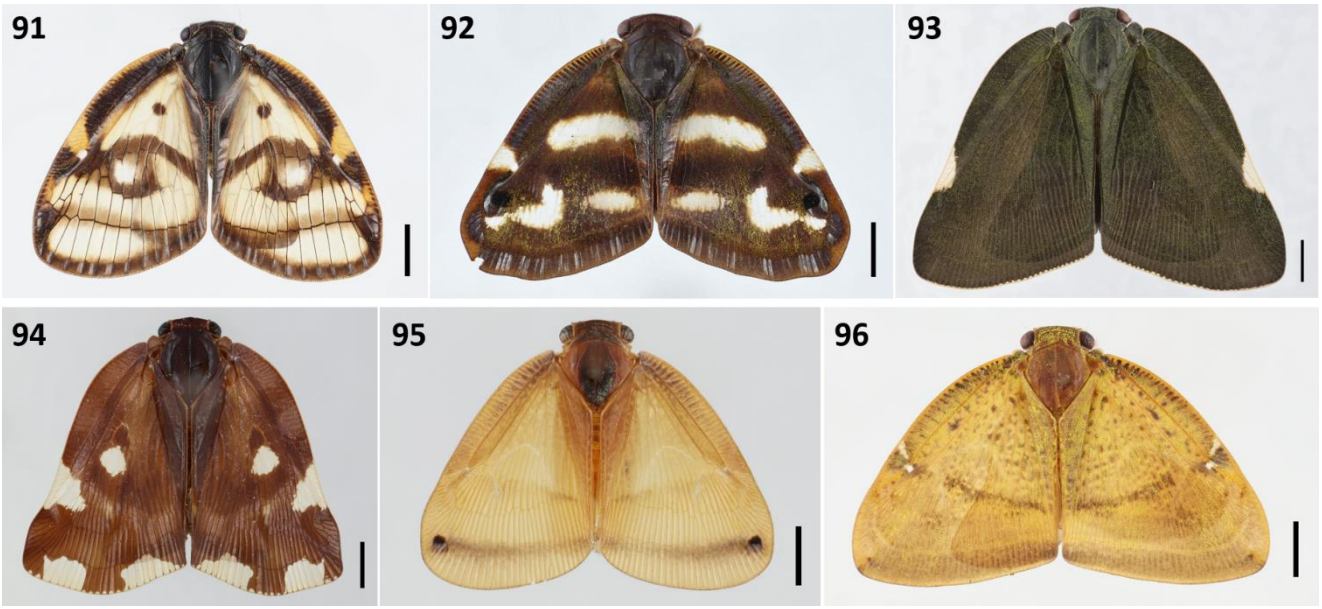

圖 91–96、廣翅蠟蟬科。91. *Euricania ocella*；92. *Ricania simulans*；93. *Ricanula sublimata*；94. *Ricania marginalis*；95. *Ricanoides flabellum*；96. *Ricanoides pipera*。比例尺均為 2 mm。

14. 軍配飛蝨科 Tropiduchidae

體小至中型，外部形態變化大，多數種類身體扁平，臺灣產的種類前翅皆為膜質，典型特徵為前翅被位於中段或近端部，由一系列橫脈相連所形成的「節線 (nodal line)」分割成兩個區域；部分種類頭部向前延伸突起而近似象蠟蟬，但可藉由前翅具有節線、後足第二跗節腹面末端兩側各具一根小刺等特徵予以區辨。寄主種類多樣 (Yang et al., 1989)。

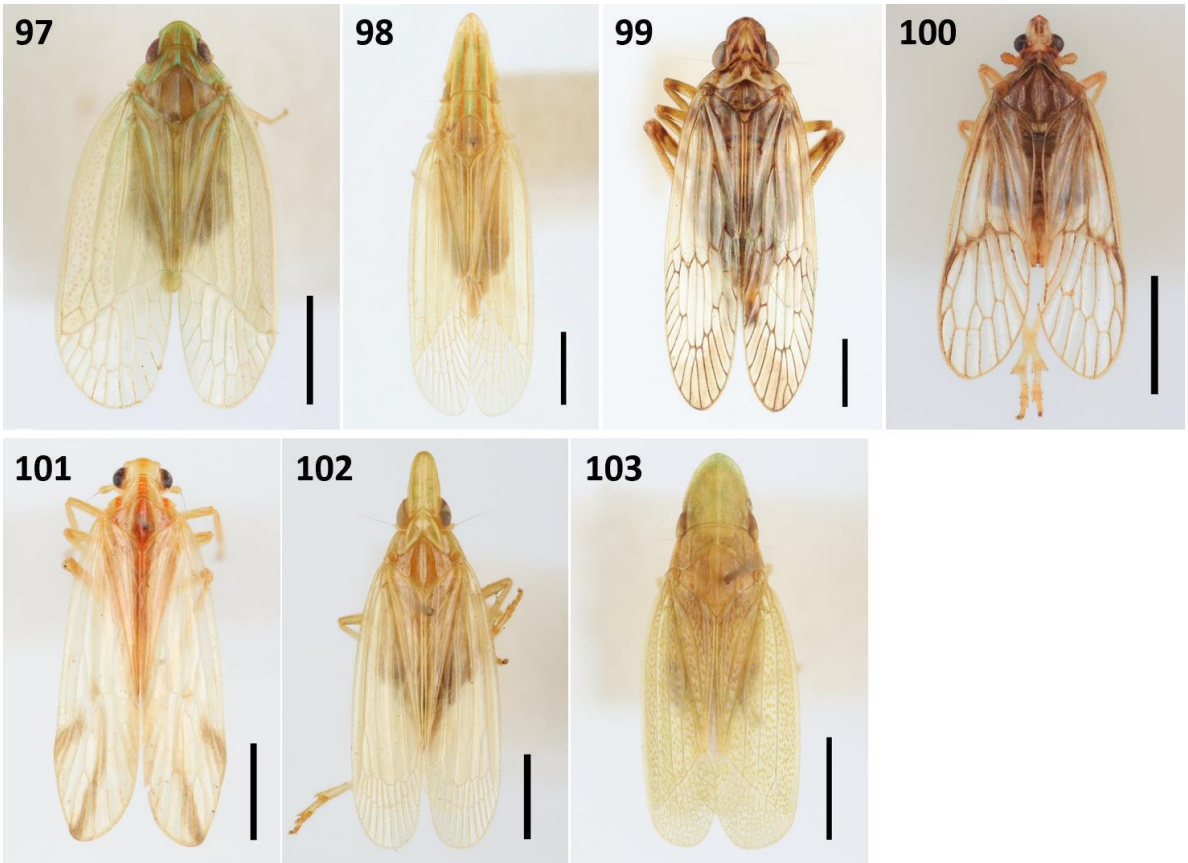

圖 97–103、軍配飛蝨科。97. *Kallitaxila sinica*；98. *Ossoides lineatus*；99. *Sogana hopponis*；100. *Neommatissus zanatus*；101. *Catullia subtestacea*；102. *Leptotambinia viridinervis*；103. *Lanshu glochidionae*。比例尺均為 2 mm。

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Identification to the Families of the Taiwanese Fulgoroidea (Hemiptera: Auchenorrhyncha)

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Abstract. The following provides a brief introduction and a pictorial key to the adults from the 14 families of Fulgoroidea known from Taiwan, including (and in accordance with the current higher classification): the Achilidae, Caliscelidae, Cixiidae, Delphacidae, Derbidae, Dictyopharidae, Flatidae, Fulgoridae, Issidae, Lophopidae, Meenoplidae, Nogodinidae, Ricaniidae and the Tropiduchidae.

Key words: Fulgoromorpha, family, key, higher classification

[研究文章 Research Article]

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First Record of *Urocerus xanthus* (Cameron, 1876) (Hymenoptera: Siricidae) from Yunnan Province, China, with Identification Keys to *Urocerus* from Mainland China and Taiwan

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Abstract. *Urocerus xanthus* (Cameron, 1876) is newly recorded from Yunnan Province, China. Adults of both sexes are illustrated and redescribed. In addition, keys to the *Urocerus* species recorded from China and Taiwan are provided. The subspecies status of *U. gigas* is also discussed.

Keywords: Taxonomy, horntail, re-description, identification, variation

Introduction

The horntails or woodwasps belonging to the family Siricidae are xylophagous insects of the order Hymenoptera. Due to the wood-boring habit of the larvae and their symbiotic relationship with basidiomycete wood-rot fungi, some species are considered to be important forest pests (Cartwright, 1938; Parkin, 1941; Slippers et al., 2003; Thompson et al., 2014). To date, ten extant genera of Siricidae are recognized, and one of the most diverse genera is *Urocerus* Geoffroy, 1762, which includes 37 species worldwide, with 21 species and subspecies known from China and Taiwan (Wei et al., 2006; Taeger et al., 2010; Sundukov, 2017; Háva & Holuša, 2018). The species *Urocerus xanthus* (Cameron, 1876) was first recorded in China by Maa (1949), and was known from Tibet and Qinghai Province in China (Xiao et al., 1983; 1992). In the present article, *U. xanthus* is newly recorded from Yunnan Province, China, and both sexes are redescribed based on newly obtained material.

In addition, during the study, the author detected some inconsistencies between the identification keys and the descriptions in Xiao et al. (1983) and (1992) (See remarks of *U. xanthus* as an example). After examining the photos of type specimens of Chinese species described by Xiao et al. (1983) and literature, I provide updated keys to adult male and female of the genus *Urocerus* of China and Taiwan.

Materials & methods

The terminology of morphological structures follows Schiff et al. (2012), except those of the head and thorax, which follows Xiao et al. (1992).

All the photographs were made by 3D Microscope with Eakins Full HD Camera, and were adjusted in GIMP (GNU Image Manipulation Program) 2.10.12.

The studied specimens in this paper are deposited in the following collections:
CAF - Chinese Academy of Forestry, Beijing, China
JHAC - Jiří HÁVA, Private Entomological Laboratory & Collection, Únětice u Prahy, Prague-West, Czech Republic.

Results

Urocerus xanthus (Cameron, 1876)

(Figs. 1-17)

Material examined: China, Yunnan, Weixi, viii.2020, local collector, 2♂♂, 2♀♀, (JHAC).

Distribution. India; Pakistan; China: Tibet, Qinghai, new to Yunnan.

Re-description of female. Length, 28 mm from front of head to apex of cornus; 34 mm from front of head to apex of ovipositor.

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稿件接受 *Accepted: 13 October 2021*
稿件出版 *Published: 25 December 2021*

Head: Black pubescence on the lower portion of the head; gena, frons, antenna and vertex with yellow pubescence. Head yellowish brown with a black, median band extending from ocellar triangle to posterior margin of vertex, surface with irregularly scattered pits except that gena almost without pit; antenna yellowish brown, with 21 flagellomeres; frons yellow, with a black spot in the middle; clypeus and supraclypeal area more densely reticulate, densely pubescent, with longest hairs on lower gena, malar area, and mouthparts; occiput with long black setae. Propleuron black, mesepisternum yellowish brown.

Thorax: Black pubescence on thorax. Pronotum yellowish brown, darkened medially and anterolaterally, matte; mesonotum black with a large, rectangular yellowish-brown patch in the middle, posterior margin yellowish brown and matte (Fig. 1B); mesoscutellum yellowish brown evenly sculptured with warts and pits; cenchrus yellowish brown. Wings uniformly yellowish infuscated, veins dark brown; hindwing with vein 1A present (Fig. 2A). Legs yellowish brown, hind basitarus a little shorter than the combine of the rest tarsomeres, hind tarsomere 2 in lateral aspect about 4 times as long as maximum height, hind tarsomere 5 about the same length of tarsomere 2, tarsal claws brownish, tarsal claw forked in lateral aspect, distal tooth rather thin and acute at apex, basal tooth thicker and shorter. (Fig. 1D), foretibial spur curved, distal half flat and rounded at apex, with a preapical spine (Fig. 1E).

Abdomen: Abdominal tergum I pubescent, yellow, anterior half brownish black, terga II-VII yellowish brown with lateral margins brownish black, tergum IX yellow, anterior margin brownish black (Fig. 2D), median basin yellowish brown (Fig. 2C); tergum X yellowish brown with a brown lateral spot on each side of anterior margin (Fig. 2B) Cornus long and narrow, linear-lanceolate, not distinctly constricted at base, the lateral margins in dorsal aspect almost parallel in the middle, the length of hind margin of median basin to cornal tip about 5.7 times as long as the maximum breadth (Fig. 2C), the upper surface mostly smooth, the lateral and lower surfaces in apical half scattered with granules or spines (Fig. 2B); cerci missing; abdominal sternum yellowish brown; ovipositor dark brown.

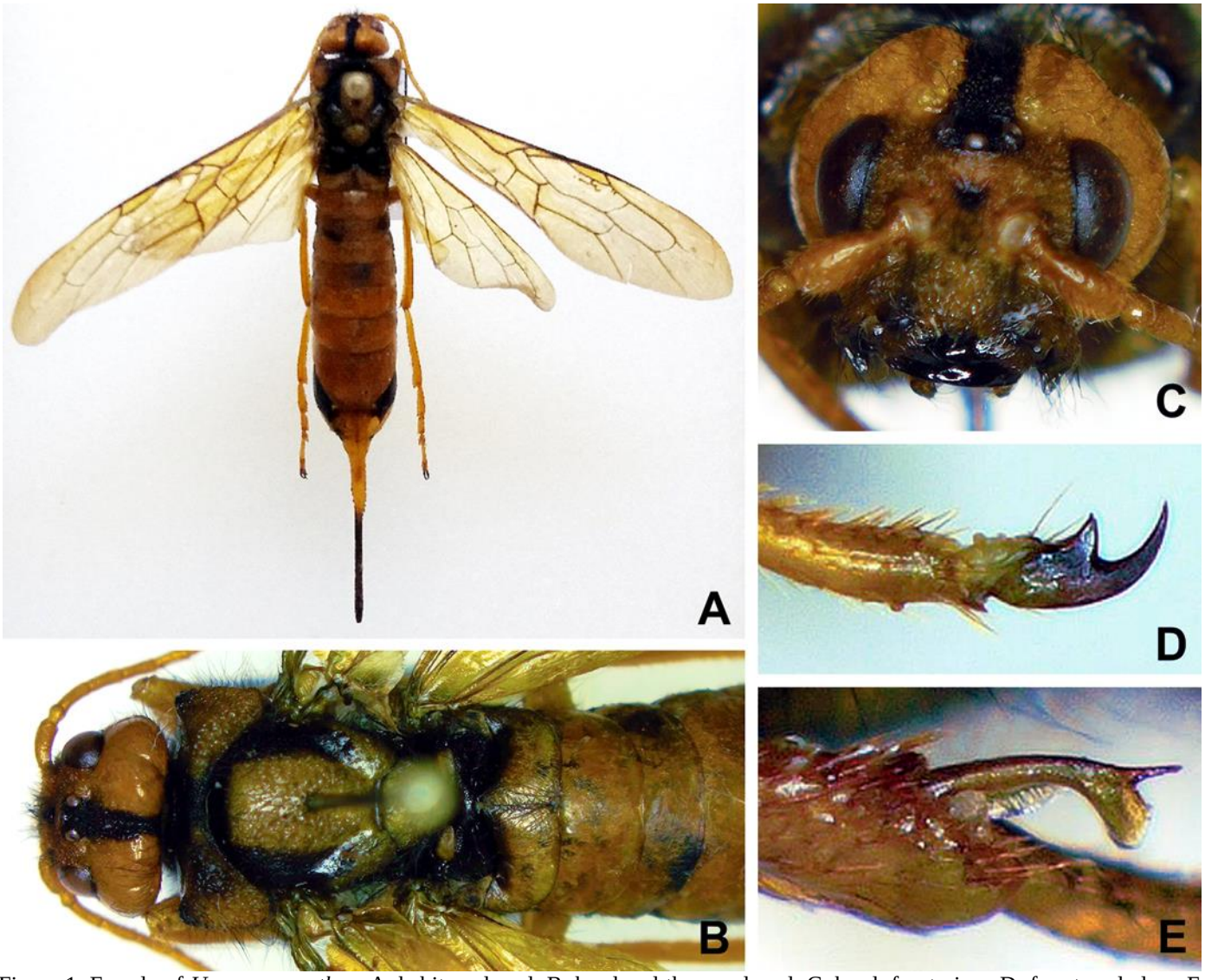

Figure 1. Female of *Urocerus xanthus*. A, habitus, dorsal. B, head and thorax, dorsal. C, head, front view. D, fore tarsal claw. E, foretibial spur.

Re-description of male. Length, 23 mm from front of head to apex of cornus. Head, pronotum, mesonotum and abdomen bicolored

Head: Black pubescence on lower portion of the head; gena, frons, antenna and vertex with yellow pubescence. Head yellowish brown with a black, median band extending from ocellar triangle to posterior margin of vertex, surface with irregular scattered pits except that gena almost without pit; antenna yellowish brown, with 18 flagellomeres; frons, area around antennal sockets and behind the dorsal margin of eyes black (Fig. 3C); clypeus and supraclypeal area more densely reticulate, densely pubescent, with longest hairs on lower gena, malar area, and mouthparts; occiput with long black setae. Propleuron black, mesepisternum yellowish brown.

Thorax: Black pubescence on thorax. Pronotum black and matte, with a pair of submedian yellowish brown spots on dorsal side; mesonotum yellowish brown and matt, black marginally (Fig. 3B); mesoscutellum brownish black, evenly sculptured with warts and pits; cenchrus yellowish brown more or less with darkened markings. Wings uniformly yellowish infuscated, veins dark brown; hindwing with vein 1A present. Fore and middle leg with femur and tibia black or brownish black and yellowish brown at both extremities, fore tarsus yellowish brown, middle basitarsus black and yellowish brown at base and apex (Fig. 4A), the rest segments of middle tarsus yellowish brown; hind femur black with both ends brownish yellow, hind tibia and basitarsus distinctly enlarged, with submarginal furrows on both dorsal and ventral surfaces, black and yellow at both extremities, hind tibia in ventral aspect about 4.7 times as long as the maximum breadth, hind basitarsus in ventral aspect about 3.3 times as long as the maximum breadth, the rest segments of hind tarsus yellowish brown, hind tarsomere 5 longer than tarsomere 2.; tarsal claws brownish; foretibial spur curved, basal half with membrane-like structure attacked, distal half flat and rounded at apex, with a preapical spine (Fig. 3D).

Figure 2. Female of *Urocerus xanthus* (Cameron, 1876). A, right wings. B, abdominal apex, lateral. C, abdominal apex, dorsal. D, abdomen, lateral.

Abdomen: Abdominal tergum I blackish brown and yellowish brown medially, terga II-VIII yellowish brown with lateral margins brownish black (Fig. 3A); cornus yellowish brown, granularly, bulging at the base, apical half triangular in dorsal aspect (Fig. 3E); abdominal sternum yellowish brown.

Remark: In the keys by Xiao et al. (1983) and (1992), the female of *U. xanthus* has the terga I-VIII yellowish brown with posterior margin blackish brown, but in their description of this species, the terga II-VII are yellowish and black laterally without the black band on posterior margin and anterior margin of tergum IX black, which is consistent with the original description by Cameron (1876), the description and illustration by Kirby (1882) as well as the female specimens examined here. The erroneous statement by Xiao et al. (1983) and (1992) has been corrected in the key below.

According to Maa (1949) and Xiao et al. (1992), the vein A1 on the hindwing of *U. xanthus* is absent. However, the vein A1 is not only present on hindwing of both sexes of our specimens, but also visible on the illustration by Kirby (1882). Schiff et al. (2012) indicated that the wing vein in Siricidae is variable and could even lead to asymmetrical venation on an individual. Therefore, the presence of vein A1 on the hindwing is considered to be variable for *U. xanthus*.

Key to the *Urocerus* species of China and Taiwan
(Adapted from Benson (1943), Maa (1949) and Xiao et al. (1992))

Male

1. Antenna black, with intermediate segments whitish yellow; body almost entirely black or brownish black, only genal and lateral spots on tergum I, VII and VIII pale . . . . . *U. antennatus*
   Antenna usually colored entirely yellow, but occasionally darkened or basoapically contrasted, but never basoapically dark with lighter coloration medially. 2

2. Body entirely black or brownish black, only the antennal flagellum, gena and apex of femur yellow . . . . . *U. yasushii*
   Body color not as above 3

3. Antenna basally black, apical half whitish yellow, sharply contrasted. . . . . *U. scienii*
   Antennae uniformly pale colored, at most gradually darkened toward the base, never sharply contrasted in basal and apical halves 4

4. Hind tibia and basitarsus apparently enlarged 5
   Hind tibia and basitarsus not apparently enlarged 9

5. Tergum brown to black; hind tibia entirely black 6
   At least terga II-VIII yellowish brown to reddish brown; hind tibia apically and basally yellowish brown 7

6. Antenna and pronotum brown; middle tibia yellow or yellowish brown . . . . . *U. multifasciatus*
   Antenna and anterolateral corner of pronotum yellowish brown; middle tibia mostly black . . . . . *U. fushengi*

7. Middle tibia entirely yellow; terga I and II brownish black, the others yellowish brown . . . . . *U. similis*
   Middle tibia not entirely yellow 8

8. Tergum entirely yellowish orange . . . . . *U. dongchuanensis*
   At least terga II-VIII yellowish orange and brownish black laterally . . . . . *U. xanthus*

9. Hairs on head and thorax exceptionally long, for instance, those between the antennal sockets are longer than the scape . . . . . *U. gigas tibetanus*
   Hairs on head and thorax of usual length, for instance, those between the antennal sockets are scarcely longer than two-thirds the scape . . . . . *U. gigas gigas*

Female

1. Cornus relatively broader and shorter, the post-cercal length much less than three-times as long as the maximum breadth (If the cercus absent, the length of hind margin of median basin to cornal tip at most 3.3 times as long as the maximum breadth), robustly lanceolate, the lateral margin in dorsal aspect markedly dilated preapically 2
   Cornus relatively slender and longer, the post-cercal length at least three-times as long as the maximum breadth (If the cercus absent, the length of hind margin of median basin to cornal tip at least 3.7 times as long as the maximum breadth), acuminate or lanceolate, the lateral margin in dorsal aspect at most only slightly dilated preapically 4

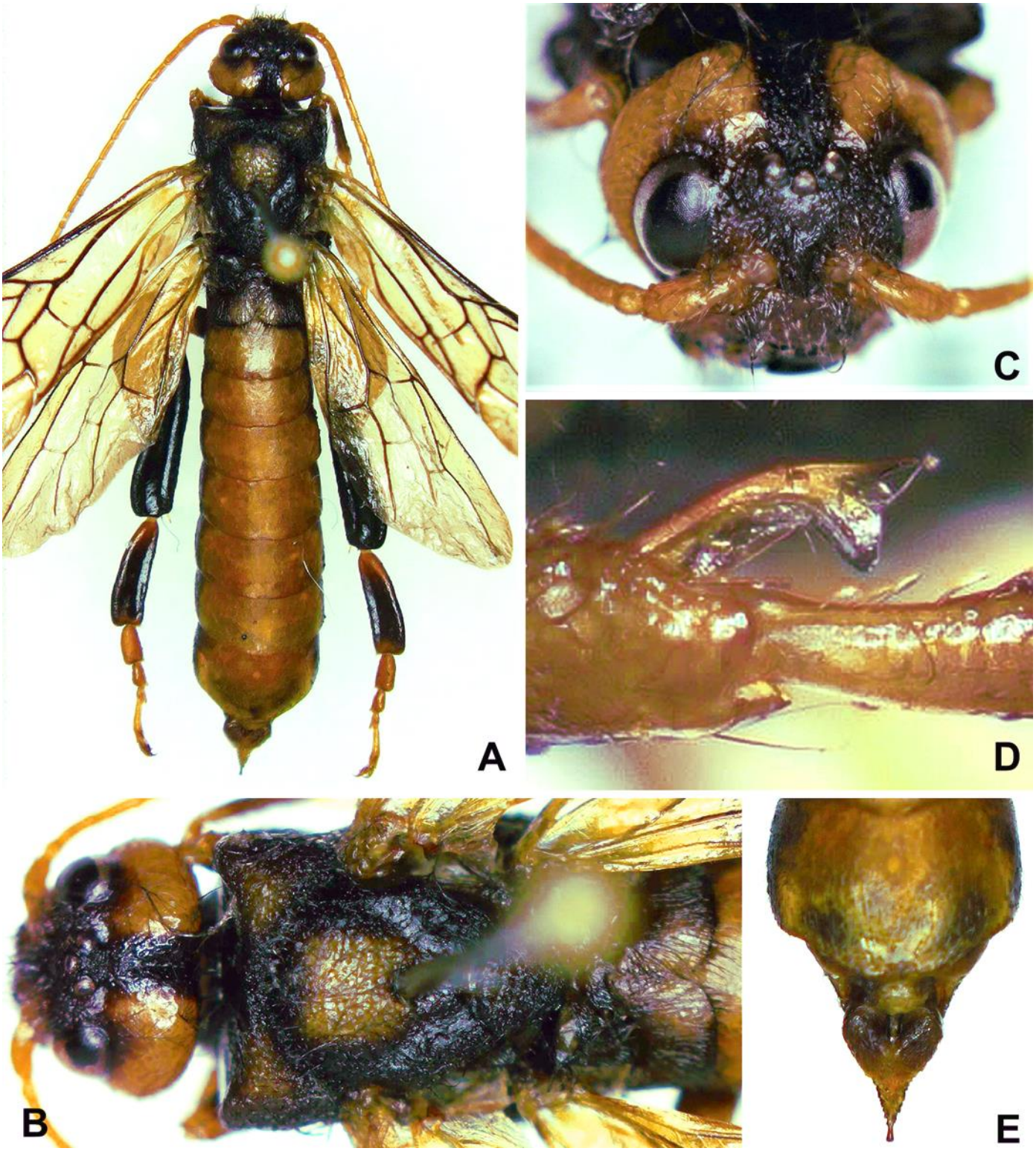

Figure 3. Male of *Urocerus xanthus* (Cameron, 1876). A, habitus, dorsal. B, head and thorax, dorsal. C, head, frontodorsal. D. foretibial spur. E, abdominal apex, dorsal.

2. Antenna black or brownish black at both extremities, with the intermediate segments whitish yellow; flagellomere I slightly longer than flagellomere II . . . . . *U. helvolus*
Antennal segments almost concolorous, black or yellowish orange; length of flagellomere I equal to or shorter than flagellomere II 3

3. Fore basitarsus longer than fore tibia; antenna black, brown at the tip, with intermediate segments slightly dilated, the apical ones strongly attenuated; tergum I yellow . . . . . *U. sicieni*
Fore basitarsus shorter than the fore tibia; antennae yellowish orange, slightly darkened at the extremity, with intermediate segments cylindrical, the apical ones slightly attenuated; tergum I reddish brown . . . . . *U. koshunus*

Figure 4. Male of *Urocerus xanthus* (Cameron, 1876). A, middle leg, lateral. B, hind leg, ventral.

4. Antenna black or brownish black at both extremities, with intermediate segments whitish yellow; body almost entirely black or brownish black 5
Antenna almost entirely yellowish brown to reddish brown, at most scape and pedicel slightly darkened, never sharply contrasted in middle and both extremities; body color not as above 6

5. Eye excessively small, with its longitudinal axis only about a-half as long as the oculo-occipital line; median black band on vertex only as wide as an eye; abdomen entirely black . . . . . *U. niger*
Eye of usual size, with its longitudinal axis about two-thirds or three-quarters as long as the oculo-occipital line; median black band on vertex much broader than an eye; terga I, VII and VIII laterally pale-marked . . . . . *U. antennatus*

6. Body entirely black or brownish black, only pale on gena, most of antenna, tibia and tarsus . . . . . *U. yasyshii*
Body color not as above 7

7. Preapical tooth of the tarsal claw lying obliquely to the main axis, excessively long; Abdomen yellowish brown, except ventral extensions of terga II-VII and anterior margin of tergum IX blackish brown . . . . . *U. xanthus*
Preapical tooth of the tarsal claw subperpendicular to the main axis, moderately long; abdomen more richly dark marked 8

8. Vertex black, or medially with a very broad, transversely rectangular or trapezoidal, black band, of which the median breadth at least twice as long as the postocellar line 9
Vertex yellow, or medially with a narrow, linear or T-shaped black band, of which the median breadth at most as broad as postocellar line 11

9. Hairs on head and thorax exceptionally long, for instance, those between the antennal sockets are longer than the scape; tergum II mostly black posteriorly . . . . . *U. gigas tibetanus*
Hairs on head and thorax of usual length, for instance, those between the antennal sockets are scarcely longer than two-thirds the scape; tergum II entirely yellow to light reddish brown 10

10. Tergum VIII entirely yellow to light reddish brown dorsally, the tergum IX mostly yellow to light reddish brown dorsally or black dorsally and discally broadly yellow in lateral aspect . . . . . *U. gigas gigas*
Tergum VIII posteriorly narrowly black in the middle, the tergum IX almost entirely black, with lateral margin more or less yellow to reddish brown . . . . . *U. gigas orientalis*

11. Hairs Vertex entirely yellow, or medially with a black or brown band, of which the median breadth at most as broad as an ocellar 12
Vertex medially with a black or brown band, of which the median breadth as long as the postocellar line. 14

12. Mesonotum entirely black; the length of the ocello-occipital line at least thrice as long as oculo-occipital line. . . . . *U. multifasciatus*
Mesonotum mostly yellowish brown or ferruginous; the length of the ocello-occipital line less than thrice as long as oculo-occipital line 13

13. Tergum mostly black, dull; the flagellomere I apparently shorter than flagellomere III . . . . . *U. linitus*
Tergum mostly yellowish brown, with brown markings on posterior margins of terga II-VIII (very pale on terga II), lusterous; flagellomere I apparently longer than flagellomere III . . . . . *U. serricornis*

14. Hind femur reddish brown to brownish black, tibia and tarsus yellow; tergum I deeply punctuated 15
Hind femur, tibia and tarsus entirely yellow or yellowish brown; tergum I shallowly punctuated 16

15. Foretibia slightly shorter than fore basitarsus, cornus relatively short, and in profile apically not curved ventrad, but sharply pointed; tergum VIII yellow anteriorly . . . . . *U. brachyurus*
Foretibia slightly longer than fore basitarsus, cornus relatively long, and in profile apically more or less curved ventrad, and not sharply pointed; tergum VIII entirely black . . . . . *U. niitakanus*

16. The vertex in frontal aspect distinctly tumescent medially, forming a lateral sulcus on each side of median groove 17
The vertex in frontal aspect not distinctly tumescent medially, distinct lateral sulcus absent . . . . . *U. tsutsujiyamanus*

17. The tergum VIII medially black anteriorly . . . . . *U. lijiangensis*
The tergum VIII yellowish brown anteriorly. 18

18. The ovipositor shorter than forewing . . . . . *U. similis*
The ovipositor longer than forewing . . . . . *U. tumidus*

The *Urocerus* species recorded from China and Taiwan
(For the references of occurrence of each species in China, please see Wei et al. (2006))

Urocerus antennatus (Marlatt, 1898)
Urocerus brachyurus Maa, 1949
Urocerus dongchuanensis Xiao & Wu, 1983
Urocerus fushengi Xiao & Wu, 1982
Urocerus gigas gigas (Linnaeus, 1758)
Urocerus gigas orientalis Maa, 1949
Urocerus gigas tibetanus Benson, 1943
Urocerus helvolus Xiao & Wu, 1983
Urocerus koshunus (Sonan, 1938)
Urocerus lijiangensis Xiao & Wu, 1983
Urocerus linitus Xiao & Wu, 1983
Urocerus multifasciatus Takeuchi, 1938
Urocerus niger Benson, 1943
Urocerus niitakanus (Sonan, 1938)
Urocerus serricornis Xiao & Wu, 1983
Urocerus sicieni Maa, 1949
Urocerus similis Xiao & Wu, 1983
Urocerus tsutsujiyamanus (Sonan, 1938)
Urocerus tumidus Maa, 1949
Urocerus xanthus (Cameron, 1876)
Urocerus yasushii (Yano, 1917)

Remarks on the subspecies status of *Urocerus gigas*: The subspecies *Urocerus gigas orientalis* Maa, 1949 was included in the checklist of sawflies of China (Wei et al., 2006). The subspecies was described based on two female specimens from Sachalin and Tschita, with the exterior surface of hind tibia with the apical fourth distinctly darkened, tergum VIII yellow and posterior margin black in the middle, and tergum IX laterally extensively yellow. Maa (1949) mentioned two additional females (not included in the type series) deposited in Musée Heude collection, one collected from Tschita, and the other from Tsingtao, Shangtung. He doubted the collecting data of the latter. According to Maa (1949), the specimen from Tschita is probably a newly emerged adult with median band on vertex exceptionally narrowed posteriorly and tergum IX broadly yellow laterally; the specimen from Tsingtao has tergum VIII entirely yellow and tergum IX extensively yellow laterally. Maa (1949) stated that the coloration of the latter should be referred to *U. g. taiganus*, instead of *U. g. orientalis*. *Urocerus gigas taiganus* was described by Benson (1943) based on specimens from Finland, northern and, southwestern Russia. Benson (1943) suggested that the female from Sachalin illustrated by Matsumura (1930) should be *U. g. taiganus*. Maa (1949) disagreed with Benson (1943), stating that such coloration described by Matsumura (1912,

1930) would run to *U. g. flavicornis*, instead of *U. g. taiganus*. He also pointed that the identification of a female specimen from Kamchatcha as *U. g. flavicornis* by Ashmead (1902) should be erroneous. Thus, Maa (1949) described the subspecies *U. g. orientalis* to accommodate *U. gigas* from East and Northeast Asia with coloration distinct from other subspecies. However, Xiao & Wu (1983) reported four female specimens of *U. g. taiganus* from a single locality in Xinjiang with three matching *U. g. taiganus* and the other matching *U. g. orientalis*, which suggests that the colorations of tergum VIII, IX and hind tibia might be variable. Smith (1978) stated that the separation of subspecies of *U. gigas* is principally only by the coloration consistent within certain geographical regions. The presence of multiple coloration forms in a single area might suggest invalidity of certain subspecies, or possibly inappropriate subspecies status. Lacking the material and ability to study the relationship among the subspecies of *U. gigas*, I follow Taeger et al. (2010, 2018) tentatively accepting *U. g. taiganus* as a junior synonym of *U. g. gigas* and *U. g. orientalis* as a valid subspecies. The validity of subspecies of *U. gigas* should be evaluated.

Urocerus flavicornis, long been considered as a subspecies of *U. gigas*, was re-elevated as full species by Schiff et al. (2012) based on molecular evidence. Schiff et al. (2012) stated that the species is distributed in Canada and United States, with interception records from Réunion Island and England. According to Wei et al. (2006), the occurrence of the species in China was reported from Inner Mongolia in "Kang, 1992". However, the exact publication or article of "Kang, 1992", nor additional record of *U. flavicornis* in China could not be traced and accessed by the author. Based on the locality, the specimens identified as *U. g. flavicornis* in "Kang, 1992" is possibly *U. g. orientalis*, and thus the record of *U. flavicornis* in China is removed until further confirmation is made.

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藏黃大樹蜂於中國雲南省之新紀錄（膜翅目：樹蜂科），及中國與臺灣產大樹蜂屬檢索表

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摘要: 本研究提供藏黃大樹蜂 *Urocerus xanthus* (Cameron, 1876) 於中國雲南省之新紀錄，並重新描述其成蟲。本文亦提供中國及臺灣產大樹蜂屬 (*Urocerus* Geoffroy, 1762)之檢索表。

關鍵詞: 分類學、樹蜂、大樹蜂屬、重新描述、鑑定、變異

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A Supplement to the Fauna of Rhipiceridae (Coleoptera) of Taiwan, and Notes on the Seasonal Occurrence of *Sandalus sauteri sauteri* Emden

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Abstract. This study is a supplement to the fauna of Rhipiceridae in Taiwan. In addition to the three documented *Sandalus* species, we added an undetermined species from Kinmen Island - Rooted in specimen examination, observation, citizen science, and literature, this study aims to provide records of the distribution and phenology of each species. Biological notes based on field observation are provided where possible. The available data indicates that *Sandalus sauteri sauteri* Emden has two seasonal occurrences: spring to early summer and fall, while other species have a single seasonal occurrence or show no clear pattern due to insufficient data. A number of *S. sauteri sauteri* were found and collected concurrently in a water tank in southern Taiwan in the early October, 2021. All 24 individuals were male, and may had drowned not long before being collected. It is likely that they were attracted to the water tank by the reflective polarized light while flying in the forest. This new finding suggests an emergence peak of *S. sauteri sauteri* in early October, which is later than the local cicada seasons and may not overlap with the latter. The phenomenon observed is largely congruent with the behavioral ecology of the Nearctic *Sandalus niger* Knoch.

Key word: Distribution, phenology, Kinmen Island, citizen science, polarized light, cicada

Introduction

Rhipiceridae is a small and poorly studied beetle family (Young & Katovich, 2002). Beetles from this family are known as cicada parasite beetles in English because their larvae are ectoparasitoids of underground cicada nymphs (Craighead, 1921; Elzinga, 1977; Moulds, 1990; Lawrence, 2016). The family is distributed in all major zoogeographic realms, though is absent from the Hawaiian Islands and New Zealand (Katovich, 2002). It comprises two subfamilies, Sandalinae (nearly globally distributed except Australia) and Rhipicerinae (Australia & South America), with eight genera and over 80 documented species (Jin et al., 2013; Lawrence, 2016). Among them, three genera and 15 species are known in Asia, namely *Arrhaphipterus* Schaum (5 spp. in West Asia and Arabian Peninsula), *Chamoerrhipes* Latreille (1 sp. in Arabian Peninsula), and *Sandalus* Knoch (Wurst, 2006; Hallan, 2011). *Sandalus* can be found in all continents of the world except Australia, including 9 species in East and Southeast Asia (China, India, Japan, Myanmar, Taiwan), 14 in Africa (Hallan, 2011), 5 in North America (Schnepp & Powell, 2018), and 13 in Mexico and South America (Pic, 1925; Emden, 1931; Blackwelder, 1944). This genus is likely to be in need of a taxonomic revision.

Research of Rhipiceridae in Taiwan is scarce. Emden (1924) described *Sandalus sauteri* Emden as the first representative species in Taiwan. Miwa (1928) reviewed the rhipicerid fauna (including current Callirhipidae) in the Imperial Japan, with *S. sauteri* in Taiwan and *S. segnis* Lewis in Japan. There had been a long research gap since then until Lee et al. (2005) revised the taxonomy of *Sandalus* in Taiwan and Japan, in which the authors noted three species in Taiwan and its southeastern islet Lanyu. *Sandalus segnis* appears in Japan and northeastern Taiwan; *Sandalus taiwanicus* Lee, Satô & Sakai is endemic to Taiwan, mainly in the southern areas of the island; *Sandalus sauteri* Emden lives in Taiwan main island and Island Ishigaki of Japan, while *S. sauteri lanyuensis* Lee, Satô & Sakai is restricted to Lanyu.

The collecting records of rhipicerids are usually rare and scattered, making it difficult to study the ecology and behavior of the family. The beetles (especially females) are occasionally spotted on tree trunks in forests in the day time, and can be collected by various traps (light, Malaise, flight interception, Lindgren funnel, chemicals) in small numbers (Fukuda, 1969; Kurosawa, 1985; Mizota & Imasaka, 1997; Iwai et al., 2001; Ohki, 2014; Freese, 2019). About a dozen *Sandalus niger* Knoch were collected following a brood of periodic cicadas (*Magicicada septendecula* Alexander & Moore) in North America (Young, 1956). Through five years of local observation, Elzinga (1977) noted the consistent appearance of *S. niger* in the fall.

In this paper we provide new information, including an undetermined species from Kinmen Island, to the fauna of Rhipiceridae in Taiwan. We focus on the geographical and phenological distribution of each species rather than their taxonomic identification

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which will be treated in a separate paper. An early October (2021) observation of *S. sauteri sauteri* in unusually high numbers in Southern Taiwan is also reported and discussed.

Material and methods

Rhipicerid specimens in Ong's personal and his friends' collection (ONG), Bin-Hong Ho's (何彬宏) personal collection (HO), and of Taiwan Agriculture Research Institute (TARI), National Museum of Natural Science (NMNS) and Taiwan Forest Research Institute (TFRI) were examined. Additional records were obtained from the internet or personal communication without specimen examination, provided that the image quality was sufficient, or the observer was regarded as experienced able to reliably make species determinations. We communicated with the collectors or observers to collect biological information of rhipicerids whenever possible. The names of localities and collectors are transliterated in Chinese and occur in parentheses when they appear for the first time. Geographical and phenological distributions of each species were presented based on data from all sources.

In early October, 2021, Jeng and his colleagues found and collected more than 20 rhipicerids concurrently during a field trip in south Taiwan. We reported our observation of this unusual event, including the identification of the beetles, as well as the ecological nature of the collecting site. Frogs observed at this collection site were identified by Dr. Chi-Shun Wu from Chinese Culture University (巫奇勳，中國文化大學), Taipei City.

Results

1. Supplement to the Rhipicerid Fauna of Taiwan

***Sandalus sauteri sauteri* Emden**

(Figs 1a, 2a-b)

Sandalus sauteri Emden, 1924: 28. – Miwa, 1928: 374; Lee et al., 2005: 440 (lectotype designation, adding to Japanese fauna).
Sandalus takizawai Nakane, 1985: 35. – Lee et al., 2005: 440 (syn.)

Material examined:

Taoyuan City: 1♀, Fuxing, Sileng (桃園市復興區，四稜), 22.VII.2017, Chen CL (陳昭良)(HO); **Taichung City:** 1♀, Heping, Baxianshan Recreation Forest (臺中市和平區，八仙山森林遊樂區), 24.V.2017, Liao CA (廖志安)(NMNS); 1♀, Heping, Liyang (林務局麗陽工作站), 9.VI.2015, on tree trunk of *Celtis sinensis* (朴樹), Shih SY (施欣言)(ONG); 1♀, same data except from entry of Malunshan hiking trail (馬崙山登山口), flying ex by net (ONG); **Changhua County:** 1♀, Shetou, Qingshuiyan (彰化縣社頭鄉，清水岩), 17.V.2015, on tree trunk, Jiang LW (蔣莉葳)(ONG); **Nantou County:** 1♀, Yuchi, Lianhuachi (南投縣魚池鄉，蓮花池), 9.X.2009, Fan YB (范義彬)(TFRI); 1♀, Puli, Nanshanxi (埔里鎮，南山溪), 10.VII.2010, Wang YT (王宇堂)(NMNS); **Chiayi County:** 1♀, Fanlu, Shanhuangmahu (嘉義縣番路鄉，山黃麻湖), 15.V.2015, overturned on road at night, Ong U (NMNS); **Tainan City:** 1♂, Nanxi, Meiling (臺南市楠西區，梅嶺), 25.IX.2016, Chen JF (陳家鋒)(NMNS); 24♂♂, Meiling, Jeng ML, Yang WT & Lai YW (鄭明倫、楊萬琮、賴郁雯)(NMNS); 1♀, Dongshan, Kantoushan (東山區，崁頭山), 2.VI.2010, daytime on tree trunk, Ong U (ONG); 1♀, same locality, 17.IV.2015, overturned on road at night, Ong U (ONG); **Kaohsiung City:** 2♀♀ & 1♀, Taoyuan, Baolai (高雄市桃源區，寶來), 4 & 18.VI.2011, daytime on tree trunk, Ong U (ONG, NMNS); **Pingtung County:** 1♀, Wutai, Jiamu (屏東縣霧台鄉，佳暮), 10.V.2015, netting on *Ulmus parvifolia* (榔榆樹), Chung YT (鍾奕霆)(TARI); 1♀, Chunri, Dahanshan (春日鄉，大漢山), 24.II.2015, Chung YT (TARI); 1♀, Shizi, Shuangliu Recreation Forest (獅子鄉，雙流森林遊樂區), 15.VI.2014, Liu TY(劉廷彥)(TARI); 1♂, Shizi, Lilongshan (里龍山), 10.VI.2014, Chen JC (陳榮章) (TARI); 1♀, Hengchun, Kenting Recreation Forest (恆春鎮，墾丁森林遊樂區), 22.X.2014, canopy bagging, Lan YC (藍艷秋)(NMNS); 1♀, same data except from Sheding (社頂), 23.X.2014, by net (NMNS); 1♀, Kenting, 25.VII.2016, Chung YT (TARI); **Hualian County:** 1♀, Xiulin, Panshi (花蓮縣秀林鄉，磐石), 16.VII.2020, dead body on forest trail, Huang D (黃福盛)(ONG); **Taitung County:** 1♀, Zhiben (臺東縣卑南鄉，知本), 11.V.2018, overturned on road at night, Huang YT (黃耀霆)(NMNS); 1♂, Taimali (太麻里鄉), 7.IX.2005, Fan YB (TFRI).

Additional records:

New Taipei City: 1♀, Bali, Bali junior high school (新北市八里區，八里國中), 23.VI.2017, Chi PW (紀博瑋); **Nantou County:** 1♀, Lugu, Xitou (南投縣鹿谷鄉，溪頭), 27.VI.2014, Chen YF (陳陽發); 1♂ & 1♀, Renai, Huisun Forest (仁愛鄉，惠蓀林場),

9-15.VI.2018, FIT, Liang WR (梁維仁); **Tainan City:** 1♀, Baihe, Dadongshan (臺南市白河區，大凍山), 28.IX.2020, Hsiao SH (蕭聖翰); **Pingtung County:** 1♂, Hengchun, Kenting Recreation Forest, 24.I.1988, Chiang CF (江志芬).

Biological note: An amateur entomologist Huang BH (黃博鴻) mentioned that he collected a number of rhipicerids in Tianzhong (彰化縣田中鎮) from May to July, 2005-2006. Most of them were females. Unfortunately, there is no existing specimen or exact records. The species is most likely *S. sauteri sauteri* according to the distribution pattern.

Distribution in Taiwan: Widespread in Taiwan main island (Fig. 3, red pentagons), from low hills to about 1500m in elevation. Adult season: January and February (sporadic), April-June, September to October.

Sandalus sauteri lanyuensis Lee, Satô & Sakai
(Figs 1b, 2c)

Sandalus sauteri lanyuensis Lee et al., 2005: 440.

Material examined:

Taitung County: 1♂, Lanyu, 26.IV.2015, on spider's web, Shih SY (NMNS); 1♂, Lanyu, 28.IV.2021, sweeping net on tall trees, Ong U (ONG); 1♂ & 1♀, Lanyu, Cross-Island Road (蘭嶼中橫), 20.IV.2021, Huang D (ONG); 2♀♀, Lanyu, 14.IV.2013, Chung YT (TARI); 1♂, Lanyu, 07.IV.2015, Chung YT (TARI); 1♀, Lanyu, 03.V.2021, Chung YT (TARI).

Additional records:

Taitung County: 1♀, Lanyu, 06.IV.2014, on tree trunk, Lin HY (林翰羽); 2♂♂ & 1♀, Lanyu, Xiaotianchi (小天池), 04.IV.2018, FIT, Ho BH.

Remarks: Females of this subspecies was not known yet in Lee et al. (2005). Herein we show the habitus with high-quality image for the first time.

Biological note: Dash Huang found a female on a tree on the Cross-Island road in a sunny morning of April, 2021. Soon after picking the female up, Huang was hit by a male rhipicerid flying nearby. Huang then put the female in the center of an open umbrella to see if she can attract more males. Several males did approach in the following five minutes but none flew directly to the umbrella. It is unclear if the males were attracted by the pheromone released by the female, or simply because the place is a flying pass due to the air flow.

Distribution in Taiwan: Lanyu (Orchid Is.) (Fig. 3, brown pentagon).

Adult season: March to early May.

Sandalus segnis Lewis
(Fig. 2d)

Sandalus segnis Lewis, 1887: 316. – Miwa, 1928: 374; Lee et al., 2005: 441 (lectotype designation, adding to Taiwanese fauna).
Sandalus semitestaceus Pic, 1906: 1. – Jakobson, 1913: 729 (syn.)

Material examined:

Nantou County: 1♀, Xinyi, Renlun forest trail (信義鄉，人倫林道), VI.2010, planted forest, pitfall, Lin LK (林良恭，計畫主持人)(HO); **Chiayi County:** 1♀, Zhuqi, Dadongshan hiking trail (竹崎鄉，大凍山步道), 14.IV.2021, Yeh LW (葉人瑋)(HO).

Remarks: This is the only *Sandalus* species in Japan main islands (Honshu and Hokkaido) (Kurosawa, 1985). Lee et al. (2005) added it to the Taiwan fauna based on a male specimen from Fushan Botanical Garden (宜蘭縣員山鄉，福山植物園). We found two female specimens from central Taiwan but no male. We followed the diagnosis by Lee et al. (2005) to identify the females and presented them herein for the first time.

Distribution in Taiwan: The record of the species in Taiwan is still scarce, only known from limited localities in NE and central Taiwan (Fig. 3, white triangles), from low hills to about 1500m high.

Adult season: March, April and July (see discussion).

Sandalus taiwanicus Lee, Satô & Sakai
(Figs 1c-e, 2e)

Sandalus taiwanicus Lee et al., 2005: 441.

Material examined:

Pingtung County: 2♂♂, Hengchun, Kenting Recreation Forest, 13.I-16.II.2005. Malaise trap, Lin CS & Yang WC (林政行 & 楊萬琮); 2♂♂, same data except 16.II-10.III.2005; 1♂, same data except 12.IV-10.V.2005 (NMNS). 1♂, Chunri, Dahanshan, 05.V.2009, daytime, Chung YT (NMNS); 1♂, Dahanshan, 28.IV.2012, Tsou MH (曹美華)(NMNS); 1♂, Dahanshan, 07.VI.2009, Chung YT (TARI); 2♂♂, Dahanshan, 04.IV.2010, flying exs by net, Ho KT (何坤達)(ONG); 1♀, Dahanshan, 26.III.2013, Lee CF (李奇峰)(TARI); 1♀, Dahanshan, 19.VI.2013, Chen JF (ONG); 1♂ & 1♀, Dahanshan, 06.IV.2015, Chung YT (TARI); 1♂, Dahanshan, 08.IV.2016, Chung YT (TARI); 1♂, Dahanshan, 04.IV.2017, Chung YT (TARI); 2♂♂, Dahanshan, 18.IV.2018, Lee CF (TARI); 3♂♂ & 1♀, Dahanshan, 28.III.2019, Chung YT (TARI); 1♀, Dahanshan, 23.IV.2021, Chung YT (TARI); 1♂, Dahanshan, 10.V.2021, Chung YT (TARI); **Taitung County:** 4♂♂, Beinan, Lijia forest trail (臺東縣卑南鄉，利嘉林道), 02.VI.2009, flying exs by net, Ong U (ONG).

Additional records:

Pingtung County: 1♂, Dahanshan, 25.III.2017, sweeping on tall trees in daytime, Tu CY (涂承諺).

Distribution in Taiwan: S and SE Taiwan (Fig. 3, yellow circles), from low hills to about 1600m high. It is not common to see sympatric distribution of different *Sandalus* species in Taiwan. This species is found sympatric with *S. sauteri sauteri* in Dahanshan and Kenting. The former species is much dominant in Dahanshan where the latter species is more common in Kenting.

Adult season: January or February to mid June.

Sandalus sp.
(Figs 1f, 2f)

Material examined:

Kinmen County: 1♀, Kinmen Is., 01.VII.1997, Chou WI (NMNS); 1♀, Kinmen Is., Jinning, Taiwushan (金門縣金寧鄉，太武山), 13.VI. 1995, Chou WI (NMNS); 1♀, Kinmen Is., Jincheng, Gugang (金城鎮，古崗), 12.VI.1999, Chou WI (NMNS); 1♂, Kinmen Is., 11.V.2009, Liao SR (廖士睿)(ONG); 1♂, Kinmen Is., 18.IV.2014, Chung YT (TARI); 4♀♀, Kinmen Is., 16.IV.2016, daytime on tree trunk, Ong Uika (王惟加)(ONG & TARI); 1♀, Kinmen Is., Jinning, 16.VI.2016, Ong U (TARI).

Additional Records:

Kinmen County: 1♀, Kinmen Is., Jinning, Zhongshan Woods (中山紀念林), 31.V.2015, Tyus Ma (馬承漢); 5♀♀, same locality, 15.VI.2016, pitfall, Lin WL (林暐倫); 1♀, Jinsha, Mashan (金沙鎮，馬山觀測所), 25.VI.2016, Liou RH (劉人豪); 1♀, Kinmen Is., Jinhu, Botanical Garden (金湖鎮，植物園), 10.VI.2016, daytime, ovipositing on tree trunk, Yu SF (余素芳); 1♀, Kinmen Is., Botanical Garden, 24.VI.2016, daytime on tree trunk of *Casuarina equisetifolia* (木麻黃), Shi LC (施禮正).

Remarks: This species has been known since late 1990s, largely on females. We presented the habitus images of both sexes of this species for the first time. It differs from the other species in Taiwan and Japan, and its taxonomy will be treated in a separate paper.

Distribution in Taiwan: Kinmen Island (Fig. 3, orange hexapedals).

Adult season: Mid April to late June (or very early July).

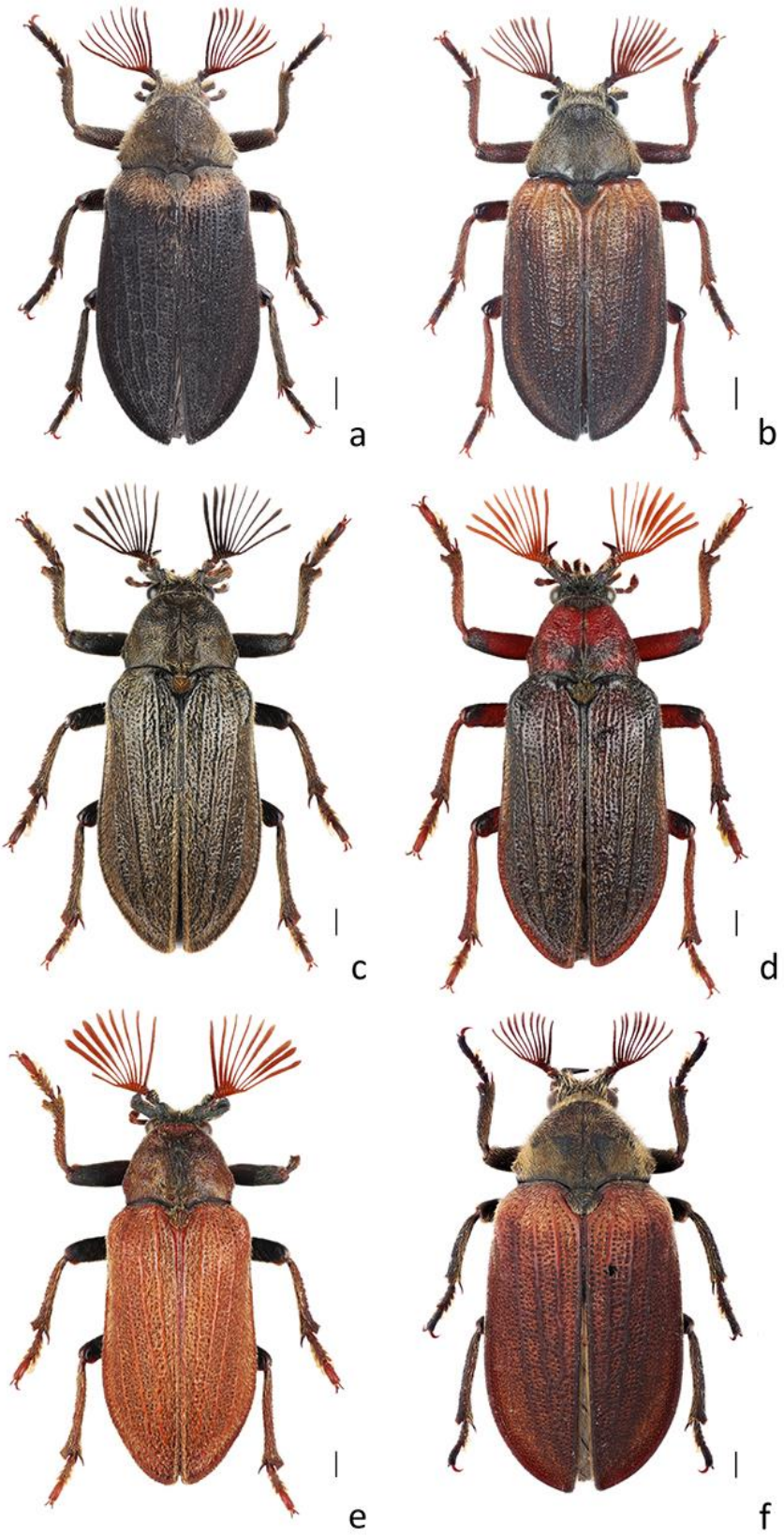

Figure 1. Habitus of males of *Sandalus* species in Taiwan and its islets: a. *S. sauteri sauteri* Emden; b. *S. sauteri lanyuensis* Lee, Satô & Sakai; c-e. *S. taiwanicus* Lee, Satô & Sakai, color variation; f. *S.* sp. from Kinmen Island. Scale bar = 1 mm.

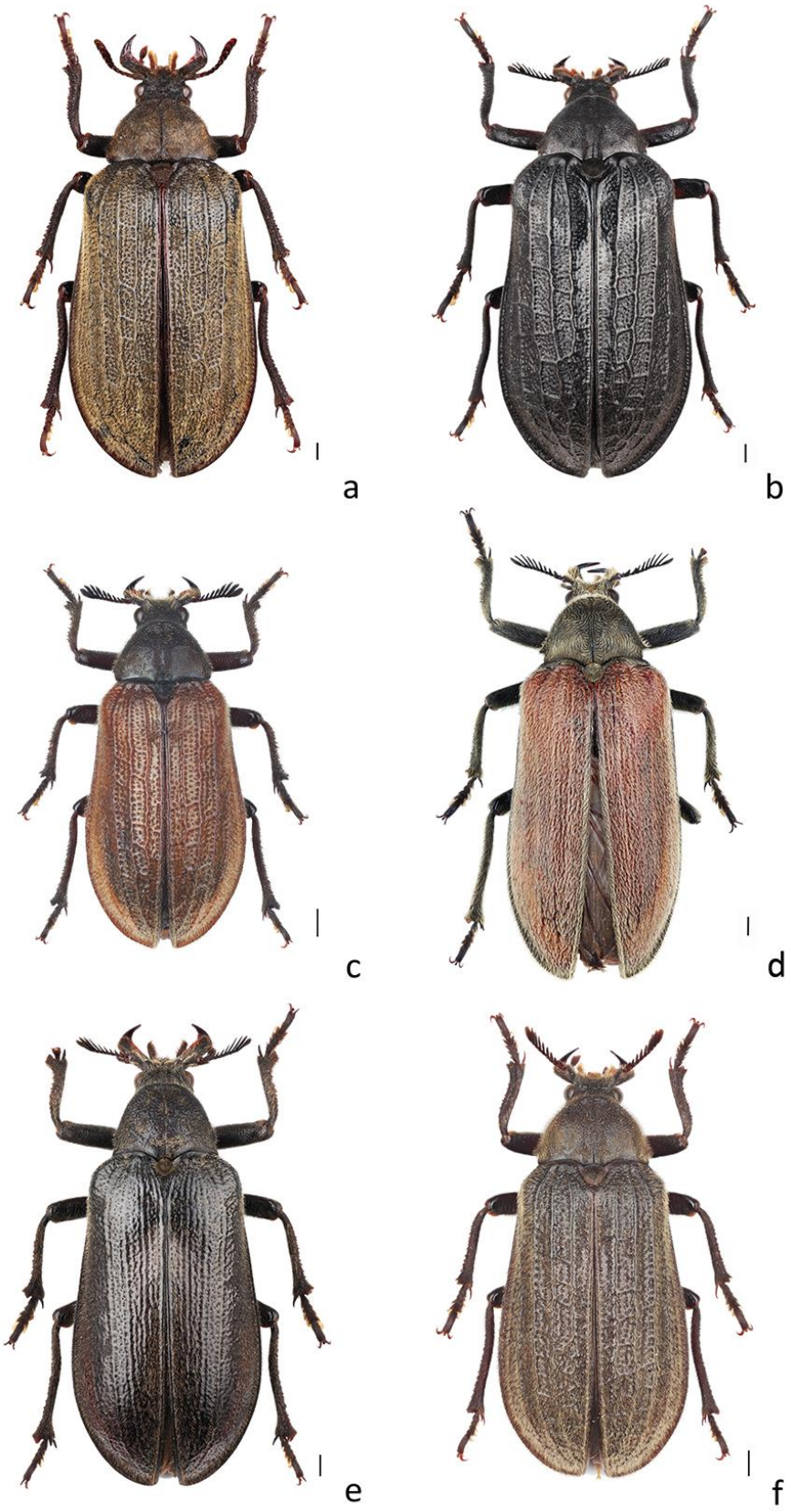

Figure 2. Habitus of females of *Sandalus* species in Taiwan and its islets: a-b. *S. sauteri sauteri* Emden, pubescence variation; c. *S. sauteri lanyuensis* Lee, Satô & Sakai; d. *S. segnis* Lewis; e. *S. taiwanicus* Lee, Satô & Sakai; f. *S.* sp. from Kinmen Island. Scale bar = 1 mm.

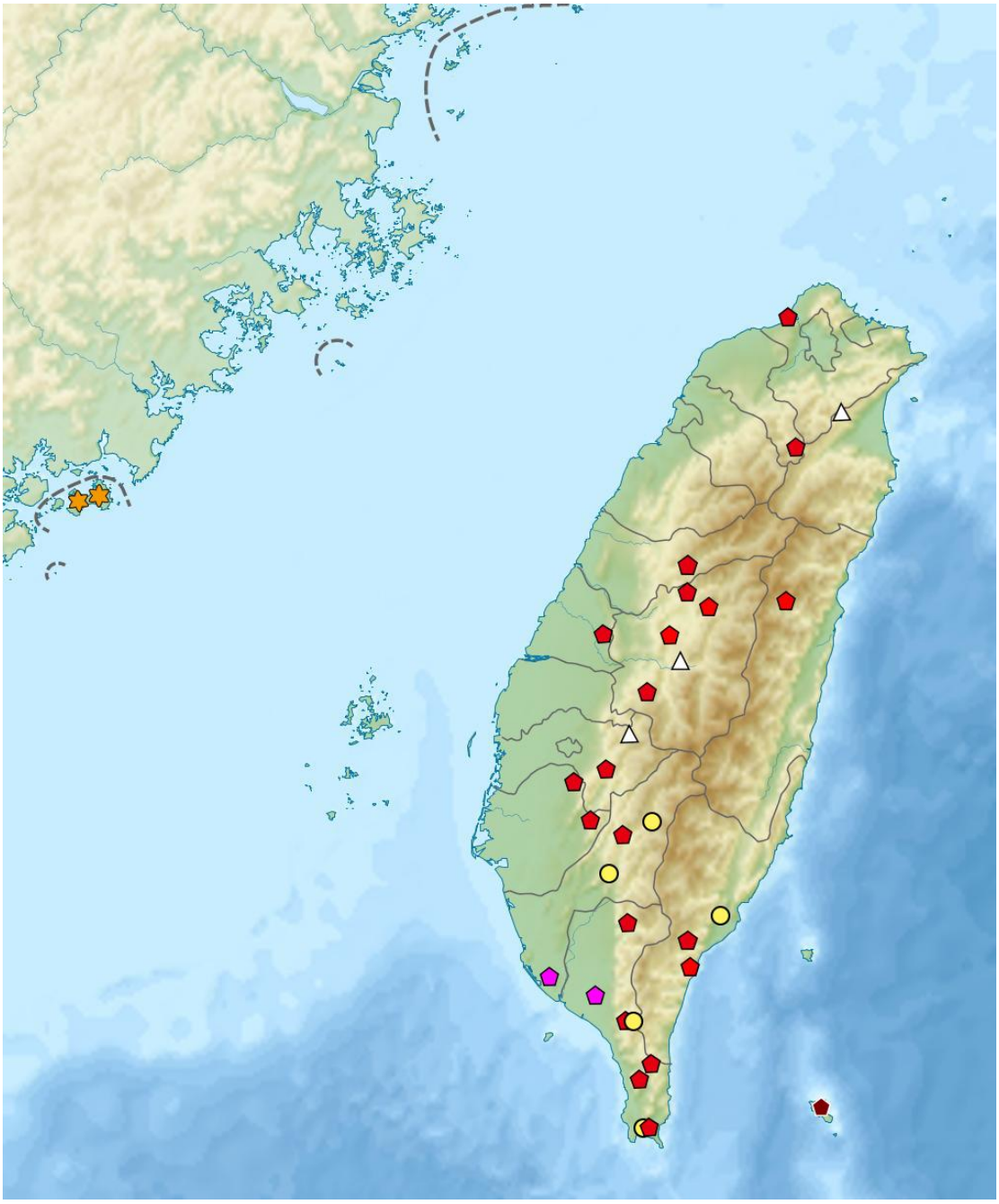

Figure 3. The geographical records of *Sandalus* species in Taiwan. Red pentagons: *S. sauteri sauteri* Emden; purple pentagons: same, records before 1930 (Hoozan 鳳山 and Raisha 來義); brown pentagon: *S. sauteri lanyuensis* Lee, Satô & Sakai; white triangles: *S. segnis* Lewis; yellow circles: *S. taiwanicus* Lee, Satô & Sakai; orange hexapedals: *S.* sp. of Kinmen Island. The top symbol means its represented species is the dominant one when two symbols are overlapped. (Basemap: Uwe Dedering, @ Wikipedia, CC BY-SA 3.0)

2. Unusually Abundant Occurrence of *S. sauteri sauteri*

On October 6, 2021 we collected 24 rhipicerids concurrently in a cement water tank in Meiling, Tainan City. All were *S. sauteri sauteri* and male, identified by microscopic examination.

Observation: The water tank is open-topped, on the east side of the mountain ridge, and about 30 meters lower than the ridge (Fig. 4). It is located in a semi-open area nearby a neglected shed on a track in an intact secondary forest (elevation 1000m). The tank was about 1.5 meters high with a diameter of 3 meters. It was full of rainwater then but nearly empty two months ago. We inspected the water tank on a warm, partially cloudy afternoon (around 15:00). Four rhipicerids were alive then and struggling on the water surface (Fig. 5), while the remaining 20 were dead or nearly so, but their bodies still intact. In addition to rhipicerids, other insects (coccindellids (*Calvia* sp.), elaterids, scarabaeids, earwigs etc.) and two dead Moltrecht's tree frogs (*Zhangixalus moltrechti* (Boulenger)) and a foam nest were present in the tank. No cicada singing was detected at this site.

The water level dropped to only 20-30cm deep and no drowned beetles were observed inside the tank when we revisited this site in November 19, 2021.

Figure 4. Overview of the water tank and its surrounding environments (Meishan, Tainan) in early October, 2021.

Figure 5. A living male of *Sandalus sauteri sauteri* struggling in the water tank.

Discussion

Among the nine named species of *Sandalus* in Asia, only those from Taiwan and Japan are better studied taxonomically (Lewis 1887; Emden, 1924; Miwa, 1928; Sakai & Sakai, 1981; Nakane, 1985; Ohno, 1995; Lee et al. 2005). However, the biology and phenology of the species in Taiwan have remained obscure owing to insufficient data (only 24 records (specimens) in the literature, see Emden, 1924; Miwa, 1928; Lee et al. 2005). The geographical and phenological distribution of *Sandalus* species in Taiwan is better understood with the additional of 110+ newly checked specimen records or observations in this study.

Sandalus sauteri sauteri has a broad distribution in the Taiwan main island, from low hills like Bali, Kenting and Shetou to mountainous forests about 1500m high in Xueshan, Alishan and Central Mountain Ranges. It has two seasonal occurrences, in late spring to early summer and in the fall. The other species each shows a trend with a single occurrence, usually in spring to summer or spring alone. It is uncertain as to whether this is due to the bias of collecting activities in different seasons or a true phenology. Records of *S. segnis* in Taiwan are still scarce, only in March, April and July. We are not sure if it is a continuous or separate seasonal occurrence. This species emerges from May to July in Japan (Fukuda, 1969; Kurosawa, 1985; Ohya et al., 1988, Iwai et al., 2001; Ohki, 2014), showing a more or less one-peaked occurrence (see Ohya et al., 1988).

Citizen Science is helpful in understanding the species distribution and phenology by providing abundant and widespread records. For example, on the basis of nearly 750 records uploaded by over 600 participants, iNaturalist (2021) demonstrates a clear seasonal peak of *S. niger* in September and October in America. In the present study, many amateurs and students also made significant contributions.

It is unusual to see two dozens of rhipicerids concurrently in a water tank. Water surfaces are known to attract or repel flying insects for various reasons (Schwind, 1991; Heinloth et al., 2018). Many insects used celestial polarized light for basic orientation. In addition to sunlight and moonlight, light reflecting off a reflective surface (e.g., water, leaves and flowers) represents another important source of polarized light in the nature (Wehner, 2001). The drowned rhipicerids were likely attracted by the horizontally polarized light reflection of the tank water while flying. This may have occurred not long before collection as some beetles were still active, and the dead ones had not decomposed. Our observation is consistent with Elzinga (1977) that the Nearctic *S. niger* takes flight only in the warm, partially cloudy to sunny afternoon for a few days in its adult life.

The reason why only males presented in the water tank is unclear. Three non-exclusive explanations are inferred:

1. It's early in the adult season, and females are still scarce.
2. Males fly more actively than females do.
3. Behavioral responses to reflected polarized light are sexually dependent.

Elzinga (1977) reported that males of *S. niger* do not feed, and live only about three days after emerging from the soil. They fly eagerly and continuously in the forests to search potential mates while females are usually motionless, staying on the tree trunks. Shinkai (2008) reported a similar observation on the Japanese *S. segnis* in a planted cedar forest. The second explanation above is thus more likely the case if *S. sauteri sauteri* shares similar behavioral ecology with the other species. This may also explain the

extreme sexual ratio (166 ♂ vs 1 ♀) of *S. segnis* collected by the hanging traps in Japan (Ohya et al., 1988). Interviews with the collectors also largely validate this sexual difference of movement for *Sandalus*.

Previously sporadic record collections of *S. sauteri sauteri* are from March to June (Lee et al., 2005). Our finding reveals another emergence peak of the species in early October in Meiling. Meanwhile, we noticed no cicada singing in the scene. This suggests that the fall occurrence of *S. sauteri sauteri* might be later than that of their host cicadas, or even without overlap with the latter. This is largely congruent with the observation of Elzinga (1977) on *S. niger* which appears from late September to mid-October in Kansas when the seasons of cicadas have ended. The females of *S. niger* lay eggs soon after mating, but the triungulin larvae do not hatch until the next spring or summer in the natural habitat (Elzinga, 1977). Therefore, the seasonal appearence of rhipicerids and their host cicadas need not be overlapping. Further study on the phenology of *S. sauteri* and the correlation between the beetles and local cicadas is needed. The water tank in Meiling may serve as a good site for long-term monitoring.

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臺灣產蟬寄甲科（鞘翅目）補遺，並記錄紹達杉蟬寄甲在本島的發生季節

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摘要: 本報告為臺灣產蟬寄甲科 (Rhipiceridae) 相之補遺，除既知的三種杉蟬寄甲 (*Sandalus*)，增列金門產的一個同屬未定種。藉由公民科學家的參與，我們蒐集整理 110 餘件新獲得之標本或目擊資料，加上文獻紀載，以進一步了解各個物種的分布與物候，並盡可能提供生物資訊。根據所得資料，紹達杉蟬寄甲指名亞種 (*S. sauteri sauteri*) 一年具有兩個發生季，其餘物種為單一發生季或因資料不足無法判定。2021 年 10 月初在南臺灣山區一處露天人工水池採得 24 隻落水的紹達杉蟬寄甲雄蟲，我們推測雄蟲落水原因可能是在林間飛行時受到水面反射之偏振光吸引所致。根據現場狀況研判蟬寄甲落水時間不很久，顯示本種在 10 月初於當地有一波羽化高峰，且晚於蟬的發生季。我們觀察到的現象與先前關於北美產的黑杉蟬寄甲的行為生態研究大致相符。

關鍵詞: 分布、物候、金門島、公民科學、偏振光、蟬

[會議回顧 Conference Review]

http://zoobank.org/urn:lsid:zoobank.org:pub:2FD3CC85-CA4E-4290-A11A-E41FA1474592

臺灣昆蟲同好會第一屆線上研討會會議回顧

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臺灣昆蟲同好會所第一屆研討會於 2021 年 6 月 27 號舉行，當時由於 COVID-19 疫情之故，全臺正處三級防疫警戒，故首屆研討會假雲端會議程式 ZOOM 以線上研討會之形式舉行。本會會友蕭昀在 2020 年 8 月參加了由研究生自行發起的日本昆蟲分類若手懇談會線上會議後，想效仿其在臺灣舉辦一個由從事節肢動物各類群研究之學生所組成的的線上研討會，讓年輕一輩學子們有個交流的機會，並於 2021 年 5 月 12 號發起提案，由林偉爵、胡芳碩、許至廷、劉興哲、謝侑廷、蕭昀 (依姓氏筆畫排列) 六位會友組織首屆研討會籌備委員會，負責會議籌辦事宜。

會議總時長約 8 個小時，參與人員總共有 300 位，有 23 位講者發表講題，包含 2 位捷克籍學者，其餘 21 位本國講者中包含大學部學生 5 位、研究生 5 位，其中甚至還有 2 位高中生。講題橫跨彈尾目 (1)、蜻蛉目 (1)、螳螂目 (2)、半翅目 (1)、脈翅目 (2)、膜翅目 (4)、鱗翅目 (1)、鞘翅目 (9)、蛛形綱 (2) 等類群，涵蓋生態、行為、分類、生理、族群遺傳等多個議題。會議結束後，籌備委員們另闢雲端會議室進行會後座談，邀請參與研討會的在學學生與各方同好們前來聊天、交換研究心路歷程，也間接促成了「臺灣的擬蠍 Pseudoscorpiones of Taiwan」臉書社團的成立，讓該類群的資訊更加流通而面向大眾。

整體而言，我們認為本次研討會在臺灣陷入三級警戒之際，促進了各類群研究人員和學生們之間的交流，並讓新進學子們有個展示成果的舞台。在未來，我們鼓勵對於有志於昆蟲自然史相關研究的學生們、或有興趣的各方同好踴躍參加，除增加自身的演講歷練以外，也讓相關研究資訊能夠更加普及。我們也預計在明年繼續舉辦線上研討會，感謝講者與所有與會人員，使大家有個友善又洋溢著「有蟲自遠方來，不亦樂乎」氛圍的一天！希望大家都能在疫情之下健康而平安的活著，我們明年見！

臺灣昆蟲同好會 謹上

講題與講者名單
List of Topics and Speakers

從分類學到生態學：昆蟲學家在環境科學中至關重要
From Taxonomy to Ecology: Entomologists are Essential in Environmental Science

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澳大利亞產蘇鐵伴生之澳蘇鐵象鼻蟲屬群的系統分類與演化初探
The Preliminary Study of Systematics and Evolution of Australian Cycad-associated Weevils of the *Tranes* Group (Coleoptera: Curculionidae: Molytinae)

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澎湖產蟲癭形態種的初步調查
A Preliminary Report of Insect Galls on Penghu Islands

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蘭花螳螂的飼養方法
Rearing Methods of *Hymenopus coronatus* Olivier, 1792

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臺灣蜻蛉目的保育現況與未來
Conservation of Odonata in Taiwan: Present and Future

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藻食亞目 - 臺灣與鄰近地區的古老且微小的水生甲蟲支系
Myxophaga - an Ancient Lineage of Minute Aquatic Beetles in Taiwan and Around

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臺灣大蕈蟲科的多樣性調查
The Study on Erotylidae Diversity in Taiwan

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臺灣的擬蠍 - 從過去到未來
Pseudoscorpions of Taiwan - From the Past to the Future

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台灣產龍蝨和牙蟲多樣性與分布
Diversity and Distribution of Diving Beetles and Water Scavenger Beetles (Coleoptera: Dytiscidae, Hydrophilidae) in Taiwan

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臺灣產擬瘦姬蜂屬（膜翅目：姬蜂科：柄卵姬蜂亞科）之分類學研究 Taxonomic Study of *Netelia* Gray, 1860 (Hymenoptera: Ichneumonidae: Tryphoninae) of Taiwan

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台灣跳蟲研究-回顧與展望
Review and Prospect: Collembola of Taiwan

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臺灣蘚棲葉蚤的起源（鞘翅目：金花蟲科：葉蚤亞科）
The Origins of Moss-inhabiting Flea Beetles in Taiwan (Coleoptera: Chrysomelidae: Alticinae)

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台灣及琉球群島的蟻形蜂分類研究
Taxonomic Researches of Bethylidae (Hymenoptera: Chrysidoidea) in Taiwan and Ryukyus

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高度分化的族群還是不同物種？整合分類學揭示台灣突眼虎甲蟲的隱蔽多樣性 Divergent Populations or Distinct species? Integrative Approach Reveals the Cryptic Diversity of *Therates* Beetles of Taiwan

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臺灣的潮間帶甲�螨
Intertidal Oribatid Mites in Taiwan

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台灣的蟻蛉
Antlions of Taiwan: Taxonomy & Diversity

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你給我安靜！昆蟲唾液蛋白、植物氣孔、與芳香物質
Silencing the Alarm: An Insect Salivary Enzyme Closes Plant Stomata and Inhibits Volatile Release

PO-AN LIN[1], YINTONG CHEN[2], DUVERNEY CHAVERRA-RODRIGUEZ[3], CHAN CHIN HEU[1], NURSYAFIQI BIN ZAINUDDIN[1,4], JAGDEEP SINGH SIDHU[5], MICHELLE PEIFFER[1], CHING-WEN TAN[1], ANJEL HELMS[6], DONGHUN KIM[7], JARED ALI[1], JASON L. RASGON[1], JONATHAN LYNCH[5], CHARLES T. ANDERSON[2] & GARY W. FELTON[1]

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臺灣地區新入侵龍眼雞隻遺傳結構分析
Genetic Structure of the Invasive Longan Lanternfly, *Pyrops candelaria* in Taiwan

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螞蟻搭便車---台灣螞蟻公民科學參與計畫
Tracking Ants on the Move---A Hitchhiking Ant Citizen Science Project

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尼泊爾埋葬蟲依時序辨識幼蟲及表現殺嬰行為
***Nicrophorus nepalensis* Display Parents-offspring Recognition and Infanticidal Behaviour with the Time Clue**

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臺灣的閹魔蟲科分類研究
A Taxonomic Study of Histeridae from Taiwan

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寬腹斧螳的體色變化與枯葉大刀螳的聽力範圍初探
Preliminary Study of Coloration Change of *Hierodula patellifera* and Hearing Range of *Tenodera aridifolia*

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「台灣脈翅總目貼圖討論區」社團紀錄統整
Integrated Record of Posts in Facebook Group "Neuropterida in Taiwan"

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Review of the 1st Online Conference of Taiwanese Society of Insect Natural History

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